APPENDICES

APPENDIX A: ACKNOWLEDGMENTS

The Department of Natural Resources wishes to acknowledge the contributions of those who participated in the planning which led to this DEIS and the preparation of the document.

DNR Management Team
William Wallace, Region Manager, Northwest Region
Jack Hulsey, Regions Operations Manager, Olympia
Kyle Taylor Lucas and Sonny Davis, Tribal Relations, Olympia
Candace Johnson, Assistant Region Manager, Northwest Region
Jeff May, District Manager, Northwest Region

2002-03 EIS Technical Support and Contributors
Matthew Barlow, cartographer, Information Technology Division, DNR
Jeff Cederholm, fish biologist, Land Management Division, DNR
Larry Dominguez, fish biologist, Forest Practices Division, DNR
Lisa Egtvedt, wildlife biologist, Northwest Region, DNR
Jenifer Gitchell, web support, SEPA Center, DNR
Bruce Glass, economist, Office of Budget and Economics, DNR
Mark Gray, fire regulation and fuel management coordinator, Resource Protection Division, DNR
Jana Greer, document assistance, Office of Budget and Economics, DNR
Alison Hitchcock, silviculturalist, Northwest Region, DNR
Sabra Hull, wetlands specialist, Land Management Division, DNR
Bryan Lu, natural resources scientist, Land Management Division, DNR
Barbara MacGregor, EIS Project Manager, Communications Division, DNR
Karen Ripley, entomologist, Resource Protection Division, DNR
Steve Saunders, SEPA Center, Asset Management and Protection Division, DNR
Dena Scroggie, web master, Communications Product Development, DNR
Anne Sharar, EIS writer, Asset Management and Protection Division, DNR
Lee Stilson, archaeologist, Land Management Division, DNR
Jason Stuart, forest engineer, Baker District, Northwest Region, DNR
Noel Wolff, geologist and forest hydrologist, Northwest Region, DNR
Billie Lynn Wyckoff, graphics support, Office of Budget and Economics, DNR

2002-03 Landscape Planning: DEIS Alternatives
Mary Dumas, facilitator, Resolution Services
Rob Kelly, facilitator, Resolution Services
William Wallace, Region Manager, Northwest Region, DNR
Jeff May, Baker District Manager, Northwest Region, DNR
Jason Stuart, forest engineer, Baker District, Northwest Region, DNR
Lake Whatcom DNR Landscape Planning Committee:

- Steve Hood, Washington State Department of Ecology, Committee Chair
- Vincent D'Onofrio, Water District 10
- Tom Edwards, Jr., Lummi Nation
- Rich Costello and Alan Looff, Washington Department of Fish and Wildlife
- Linda Marrom, citizen
- Dan McShane, Whatcom County
- Richard Rodriguez, Washington State Department of Health
- Clare Fogelsong and Bill McCourt, City of Bellingham
- Alan Soicher, citizen

APPENDIX B: DISTRIBUTION LIST

The Lake Whatcom Landscape Plan Draft Environmental Impact Statement is published on the DNR Internet website at http://www.dnr.wa.gov. In addition, print copies were distributed to:

Senator Harriet Spanel
Senator Dale Brandland
Representative Kelli Linville
Representative Dave Quall
Representative Doug Erickson
Representative Jeff Morris
Pete Kremen, Whatcom County Executive
Dan McShane, Whatcom County Council, Chair
Ken Dahlstedt, Skagit County Commission, Chair
Mark Asmundson, Bellingham City Mayor
Terry Bornemann, Bellingham City Council, President
Narcisco Cunanan, Nooksack Tribe, Chair
Darrell Hillaire, Lummi Nation, Chair
Lake Whatcom Forestry Forum
People for Lake Whatcom
John Guenther, Whatcom County Planning Department
Brandon Black, Skagit County Planning Department
Jim Neher, Whatcom County Water District 10
Jane Lowrey, Bellingham Public Library
Dr. Richard Gantman, Mt. Baker School District
Dr. Dale Kinsley, Bellingham School District
Environmental Coordinator, Washington State Department of Ecology
Julie Klacan, Washington Department of Fish and Wildlife
Robert Warriner, Washington Department of Fish and Wildlife
Brendan Brokes, Washington Department of Fish and Wildlife
Brian Williams, Washington Department of Fish and Wildlife
Lake Whatcom DNR Landscape Planning Committee:
- Steve Hood, Washington State Department of Ecology
- Clare Fogelsong, City of Bellingham
- Richard Rodriguez, Washington State Department of Health
- Vincent D'Onfrio, Water District 10
- Rich Costello, Washington State Department of Fish and Wildlife
- Dan McShane, Whatcom County
- Tom Edwards, Jr., Lummi Nation
- Linda Marrom, citizen
- Alan Soicher, citizen

CERTIFICATION OF ENROLLMENT

ENGROSSED SECOND SUBSTITUTE SENATE BILL 6731

Chapter 205, Laws of 2000

56th Legislature
2000 Regular Session

LAKE WHATCOM LANDSCAPE MANAGEMENT

EFFECTIVE DATE: 6/8/00

Passed by the Senate March 7, 2000
YEAS 44 NAYS 0

BRAD OWEN
President of the Senate

Passed by the House March 1, 2000
YEAS 98 NAYS 0 CERTIFICATE

I, Tony M. Cook, Secretary of the Senate of the State of Washington, do hereby certify that the attached is ENGROSSED SECOND SUBSTITUTE SENATE BILL 6731 as passed by the Senate and the House of Representatives on the dates hereon set forth.

CLYDE BALLARD

Speaker of the
House of Representatives

TONY M. COOK
Secretary

FRANK CHOPP

Speaker of the
House of Representatives

Approved March 29, 2000

FILED

March 29, 2000 - 2:59 p.m.

GARY LOCKE
Governor of the State of Washington

Secretary of State
State of Washington

ENGROSSED SECOND SUBSTITUTE SENATE BILL 6731

AS AMENDED BY THE HOUSE

Passed Legislature - 2000 Regular Session

State of Washington 56th Legislature 2000 Regular Session

By Senate Committee on Ways & Means (originally sponsored by Senators Spanel and Gardner)

Read first time 02/08/2000.

AN ACT Relating to Lake Whatcom; and creating a new section.

BE IT ENACTED BY THE LEGISLATURE OF THE STATE OF WASHINTON:

{+ NEW SECTION. +} Sec. 1. The Lake Whatcom landscape management pilot project is created.

The department of natural resources shall develop a landscape plan regarding state-owned forest lands in the Lake Whatcom watershed area. Where appropriate, the department will consult with other major forest landowners in the watershed and shall involve watershed residents in management activities. The department shall consult with the Lake Whatcom management committee for the development of the landscape plan, to review the site-specific activities and make recommendations. The interjurisdictional committee shall include two members of the public who have an interest in these activities. The landscape plan shall address at least the following topics:

(1) Establishing riparian management zones along all streams, as classified under chapter 4, Laws of 1999 sp. sess. The department shall manage lands within such zones to protect water quality and riparian habitat. The interjurisdictional committee may recommend to the department restrictions upon timber harvest and yarding activities on a case-by-case basis;

(2) Harvest and road construction upon potentially unstable slopes shall be carefully regulated;

(3) On unstable slopes, new road construction shall be prohibited and old road reconstruction shall be limited;

(4) A sustained yield model specific to the Lake Whatcom watershed that encompasses the revised management standards and that is consistent with the sustained yield established by the board of natural resources shall be created and implemented;

(5) The department should build on the existing draft Lake Whatcom landscape plan and incorporate both new information from the community and new scientific information when available; and

(6) The development of a road management plan for the watershed. The landscape plan shall be completed and implementation initiated by June 30, 2001. Timber harvest and all road construction in the watershed on state land shall be delayed until the plan is completed.

Passed the Senate March 7, 2000.

Passed the House March 1, 2000.

Approved by the Governor March 29, 2000

Filed in Office of Secretary of State March 29, 2000

APPENDIX D: ASSESSMENT INFORMATION FOR DEIS

Comparison of Three Landscape Management Alternatives for Lake Whatcom, with Specific Reference to Potential Revenues from Carbon Sequestration, Forest Product Certification, and Recreation

News Release No. 03-095: Commissioner Doug Sutherland Announces Next Step in Independent Assessment of State Trust Land Forestry

Stand Development Modeling for Lake Whatcom Watershed

Study Work Plan: Measurement of Mercury in Fish in Response to Prescribed Fire in a Boreal Forest Ecosystem

Tribal Cultural Resources Table

Bibliography for DEIS

Comparison of three landscape management alternatives for Lake Whatcom, with specific reference to potential revenues from carbon sequestration, forest product certification, and recreation

By Bruce Glass, September 3, 2003

Results of the financial analyses of the various alternatives for management of trust lands in the Lake Whatcom landscape are displayed in Table DEIS4-1. These results include only timber revenues captured by the department, and are based on an analysis that assumed the services of the land were obtained for no cost. Therefore the results presented in Table DEIS4-1 should be interpreted as a financial analysis rather than either an economic or benefit-cost analysis.

Table DEIS4-1: Results of a financial analysis of three timber production management alternatives for Lake Whatcom landscape region, at a 5% real annual discount rate

Alternative	Net present value of timber production ($000)	Difference in net present value relative to Base Case ($000)	Annualized difference in net present value relative to No Action Alternative ($000/year for 200 years)
No Action	32,118	0	0
Preferred	20,851	-11,267	-563
Alternative 3	4,540	-27,578	-1,379

Note: Values are rounded; Log volume units are based on Scribner log rules

In accordance with department policy (p. 25, Policy No. 12, Forest Resource Plan, Department of Natural Resources, 1992), the comparison of alternatives is carried out using a specified real annual discount rate. At present this rate stands at 5%, the rate used for this analysis.

The reference alternative used in this portion of the Draft Environmental Impact Statement (DEIS) is the No Action Alternative. For a detailed description of management and other assumptions defining each alternative, refer to the Comparison of Alternatives. Also, a glossary of terms used in the analysis is available in the appendices to the PDEIS (Glass, 2002).

Note that while benefits and costs not accruing to land management are deliberately and specifically excluded from the results presented in Table DEIS4-1, this is not to imply such benefits and costs do not exist. Indeed, these non-included benefits and costs can sometimes be very significant in their magnitude.

Marked differences between landscape management alternatives are apparent in Table DEIS4-1. From a strictly financial perspective, selection of a management alternative with a lower financial return than the alternative with the highest return ought to imply that the difference in return might at least be partially justified by offsetting (net) returns the department could capture from other potential revenue sources. Some potential sources capable of producing such offsetting capturable revenue streams were identified as part of the scoping and consultation process, and include: (1) Carbon sequestration; (2) Certification of forest management practices; and (3) Recreation.

Estimates of capturable net returns from carbon sequestration, certification of forest management practices, and recreation are highly uncertain. A breakeven analysis approach was adopted in addressing the analytical challenge posed by this uncertainty. Policy decision-makers can thus use the comparative breakeven information to make findings as to the degree to which differences in financial returns from adopting particular courses of timber management are likely to be offset by potential returns from these other sources.

Carbon sequestration

Two important factors affecting the potential returns from carbon sequestration are discussed in the appendices to the PDEIS, as is the method for estimating the amount of sequestered carbon for each landscape alternative (Glass, 2002). Note that the approach used is not a full-fledged economic valuation of the likely carbon sequestered under each management alternative, for reasons also outlined in the appendices to the PDEIS.

The results of this analysis are shown in Table DEIS4-2 below. The results indicate that at a 5% real discount rate, the carbon credit breakeven value is about $27/ton.

Table DEIS4-2: Derivation of breakeven values for additional carbon sequestered in two management alternatives for the Lake Whatcom landscape compared with a Base Case alternative, at a 5% real annual discount rate

Alternative compared with No Action Alternative	Difference in net present value relative to No Action Alternative ($000)	Difference in average growing stock volume relative to No Action Alternative (mmbf)	Difference in average total site carbon relative to No Action Alternative (000 tons)	PV of breakeven value of carbon credit ($/ton)
Preferred	-11,267	45	398	28
Alternative 3	-27,578	114	1,004	27

Note: Values are rounded; Log volume units are based on Scribner log rules

Using the same approach outlined in the Technical Appendices to the PDEIS (Glass, 2002), the maximum breakeven value for carbon sequestered using management regimes similar to those simulated for the Lake Whatcom landscape is likely to be less than $4/ton for the $75-700/acre range of timberland values, at a real discount rate of 5% per year. Even for (bare) land values as high as $2,000/acre, the breakeven carbon value at which a timberland owner would be indifferent to harvesting a stand for timber as opposed to retaining it for sequestration purposes would still be less than about $10/ton, as opposed to the equivalent $27-28/ton estimates presented in Table DEIS4-2. These estimates are consistent with the PDEIS findings, i.e., for the given price and yield assumptions, additional carbon sequestered in the Preferred Alternative and Alternative 3 is likely to be very much more expensive than the alternative approach of deliberately growing a tree crop for carbon sequestration.

Certification of forest management practices

The notion that price premia for certified lumber constitute a potential revenue source that could offset cost differences between land management alternatives is discussed in the appendices to the PDEIS, as are certain of the underlying assumptions and the method for calculating breakeven price premia (Glass, 2002). Note that, for reasons also outlined in the appendices to the PDEIS, this break-even analysis should not necessarily be interpreted as a case for not undertaking certification. Also, an underlying assumption of the analysis presented here is that the Lake Whatcom landscape can in fact achieve certified status, and independently of other landscapes managed by the department, if necessary.

Results are presented in Table DEIS4-3 below. Assuming the Preferred Alternative and Alternative 3 also include costs associated with certification of forest management practices[1], the breakeven analysis indicates that the forest grower would need to recover average stumpage price premia of about $103/mbf in present value terms under the Preferred Alternative (Table DEIS4-3). To put the matter another way, certified lumber produced from sawlogs originating from DNR-managed land in the Lake Whatcom landscape area would have to return a lumber price premium of at least $103/mbf, assuming this price premium was passed back to the grower in its entirety. Under Alternative 3, the price premium would need to be more than 10 times greater. For comparison purposes, the market price of green Douglas fir 2 × 4 standard and better grade, random length lumber at Portland (OR) was $290/mbf for calendar year 2002, while the average stumpage DNR received for sales sold in the same period was some $269/mbf.

[1] Since the alternatives do not actually include these costs, the differences in returns potentially understate the magnitude of the actual differences in returns between the reference and other alternatives.

Table DEIS4-3: Implied price premium for certified lumber required in the stumpage market in order for the tree grower to breakeven on the net revenue differences between two proposed landscape management alternatives for the Lake Whatcom landscape, and the Base Case alternative, at a 5% real annual discount rate

Alternative compared with No Action Alternative	Annualized difference in net present value relative to No Action Alternative ($000/year)	Average annual harvest (mbf/year)	Average annual lumber outturn based on average annual harvest (mbf/year)	Implied price premium for certified lumber the tree owner needs to receive to break even ($/mbf)
Preferred	-563	2,730	5,460	103
Alternative 3	-1,379	492	984	1,401

Note: Values are rounded; Log volume units are based on Scribner log rules

Recreation

Evaluation of the potential for earning recreation revenues in order to offset reductions timber harvest revenues centered on examining potential returns from a hypothetical destination resort. The rationale underpinning this approach is outlined in the appendices to the PDEIS (Glass, 2002).

Annual lease rental revenues from a hypothetical destination resort development were estimated at (an optimistic) $200,000 per year, falling well short of what would be needed in the way of an annual revenue flow to compensate for the annualized difference in net present value between the No Action Alternative, and the Preferred Alternative and Alternative 3 (Table DEIS4-4). Additional revenues could be expected from associated leasing of State-owned aquatic lands, but these revenues are likely to be relatively small and could not be used to compensate the upland trusts for foregone timber harvest.

Table DEIS4-4: Comparison of estimated ground rent for an hypothetical resort development on Lake Whatcom waterfront, with the difference in estimated annual revenues for two landscape management alternatives with the No Action Alternative, at a 5% real annual discount rate

Alternative compared with No Action Alternative	Annualized difference in net present value relative to No Action Alternative ($000/year)	Annual ground rent from hypothetical destination resort development ($000/year)	Difference ($000/year)
Preferred	-563	200	-363
Alternative 3	-1,379	200	-1,179

Note: Values are rounded; Log volume units are based on Scribner log rules

Indirect impacts

Indirect impacts and multiplier effects have not been examined as part of this analysis, for reasons described in the appendices to the PDEIS (Glass, 2002).

Conclusions

- Under the given price, yield, and discount rate assumptions, returns for carbon sequestered in the Lake Whatcom landscape (if any) would probably not produce revenues sufficient to justify choice of either the Preferred Alternative or Alternative 3 over the No Action Alternative on financial grounds alone.

- Assuming certification can be implemented for the Lake Whatcom landscape, any price premium associated with producing certified softwood lumber would have to return at least $103/Mbf to the forest grower, in order to financially justify choosing the Preferred Alternative over the No Action Alternative, at a 5% real discount rate. The equivalent value for Alternative 3 is even higher. It appears highly unlikely that a premium of even $103/MBF is likely to be realized by a forest grower producing certified sawtimber, especially in the context of current lumber and stumpage prices.

- Estimated lease revenues from a hypothesized destination resort development on the shores of Lake Whatcom are unlikely to completely offset timber harvest revenues forgone under either the Preferred Alternative or Alternative 3 landscape management alternatives.

- It appears highly unlikely that combined revenues from carbon sequestration, certified lumber production, and leasing of trust land for recreation activities could justify, on financial grounds alone, the choice of either of the Preferred Alternative or Alternative 3 over the No Action Alternative.

References

Department of Natural Resources. 1992. Forest resource plan. Policy plan. July 1992. Washington State Department of Natural Resources. Olympia, Washington, USA.

Glass, B.P. 2002. PDEIS-4: Comparison of landscape management alternatives for Lake Whatcom, with specific references to carbon sequestration, forest product certification, and recreation values. *In:* Department of Natural Resources. 2002. Appendices to preliminary draft environmental impact statement. Lake Whatcom. September 13, 2002. Washington State Department of Natural Resources. Olympia, Washington, USA.

NEWS RELEASE No. 03-095
August 26, 2003
Contact: Todd Myers, (360) 902-1023

Lands Commissioner Doug Sutherland Announces Next Step in Independent Assessment of State Trust Land Forestry

DNR will examine costs and benefits of "Certification" using assessment by Scientific Certification Systems

OLYMPIA – Washington Department of Natural Resources (DNR) took another step in examining the costs and benefits of "certification" of state trust forests with an independent assessment of state lands forestry, meeting with Scientific Certification Systems (SCS), an independent third party auditor performing the assessment. The update assessment included a five-day field audit conducted by an interdisciplinary team convened by SCS.

"This independent assessment will help determine the costs and benefits of certification," said Commissioner of Public Lands Doug Sutherland. "While they are assessing whether we meet their guidelines, we will be measuring whether their guidelines allow us to adequately generate revenue for schools and counties, create healthy ecosystems, and provide benefits for all the people of Washington."

This is an update of a previous Forest Stewardship Council (FSC) assessment conducted in 2000/2001. SCS, an FSC-accredited certification body, conducted the prior assessment and it will complete the update assessment.

The team spent one day in discussions with DNR personnel in Olympia and four days examining field operations. When released, the assessment report will address strategies used by DNR to meet its obligations to generate revenue for schools and counties, create healthy ecosystems, and provide benefits for all the people of Washington.

Funding to undertake a Sustainable Forestry Initiative (SFI) pre-assessment has also been secured, with pre-assessment work to be completed by Bureau Veritas Quality International (BVQI) in September of this year.

"Washington's forests are managed to some of the highest environmental standards in North America," said Sutherland. "Certification may provide us an opportunity to benefit from that good stewardship."

The Pinchot Institute for Conservation, of Washington, D.C., has arranged for private funding for the two assessments. Pinchot, which promotes sustainable forest management, has placed a high priority on fundraising for these two assessments of Washington forested trust lands, because it

will be the first time in the U.S. that these assessments will be done on large state-owned forests, held in trust to provide financial support to schools and other designated beneficiaries.

The Washington State project is also a benchmark certification project for another unique reason.

(MORE)

"For the first time in the United States, a major home center store retailer has stepped to the plate to help finance forest certification on public forestlands," states Catherine Mater, Senior Fellow of the Pinchot Institute and project manager for the Institute's certification projects. Lanoga Corporation, one of the largest and fastest growing suppliers of quality building products to professional builders and do-it-yourselfers in the United States, with over 60 Lumbermen's Building Center stores throughout Oregon and Washington, is providing a generous grant to the Pinchot Institute to allow the Washington project to move forward. "Lanoga becomes the first retailer in the United States to underscore the importance of getting certified wood products to their consumers by supporting certification efforts on public forestlands," said Mater. Lanoga Corporation is currently certified under FSC to sell FSC-certified product to their customers.

Under the Pinchot program, DNR will also be performing a "reverse assessment" of the certification assessment processes. The reverse assessment will examine:

- The relevance of the certification standards to Washington state-owned trust lands, considering biological, economic, and social issues.
- The science behind the certification standards and any recommendations of the assessment team.
- The qualifications and objectivity of assessment team members and the transparency and professionalism of the assessment processes.
- The potential usefulness of the assessments to the State Board of Natural Resources as it considers future policy for forested state trust lands, considering both costs and benefits of certification.

At the conclusion of the FSC assessment, SCS will present its findings in a written report.

Revenue for schools and other beneficiaries, and more

DNR, led by Commissioner of Public Lands Doug Sutherland, manages about 5.6 million acres of state-owned forest, aquatic, agricultural and urban lands for long-term benefits to current and future trust beneficiaries and other residents of the state.

Since 1970, DNR-managed lands have produced more than $5.7 billion in revenue, reducing the need for taxes to pay for public projects and services. By law, state-owned trust lands are to be managed to produce income for schools, universities, prisons, state mental hospitals, community colleges, local services in many counties, and the state general fund; they are also to be managed to offer fish and wildlife habitat, and provide educational and recreational opportunities to more than 11 million people each year.

# # #

DEIS Appendix D:
Stand Development Modeling for the Lake Whatcom Watershed

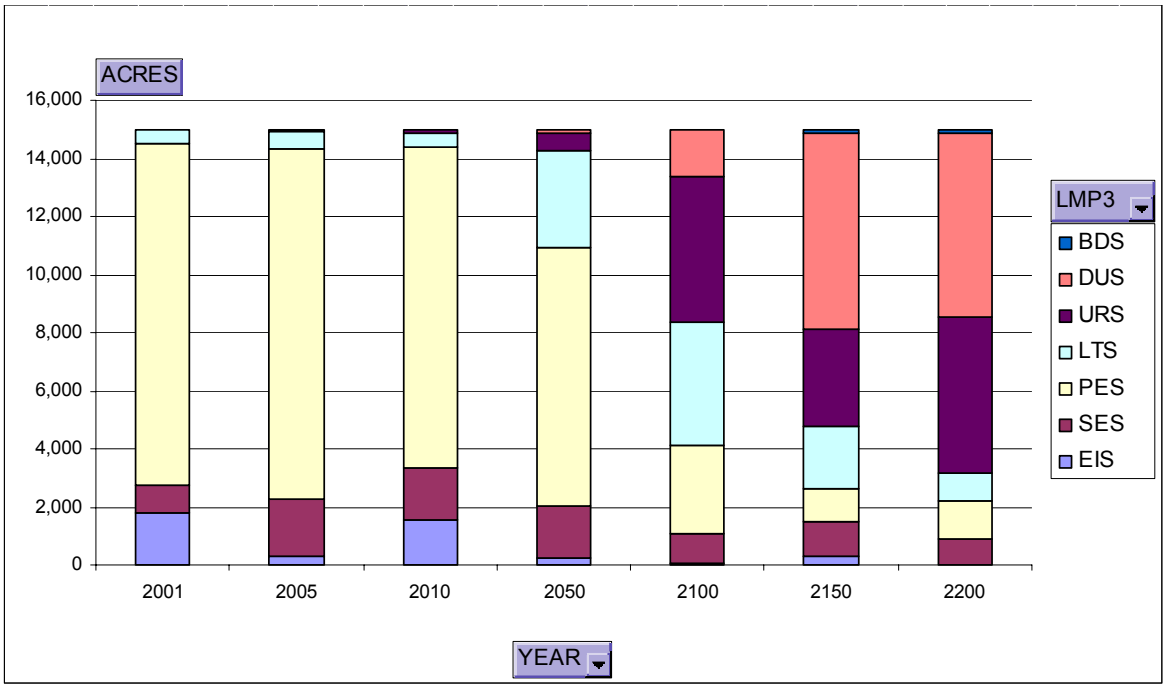
DNR, in work on the Sustainable Harvest Calculation, has developed a stand structure classification system to describe the forest in terms of stand structure and ecological development to assist with its management of habitat. Earlier efforts to describe habitat components have relied heavily on age class within forest stands. DNR anticipates that this classification too will change over time, as scientific and management knowledge grows. The classification system was based on research by Johnson and O'Neill (2001). DNR has summarized very detailed forest structures into 19 stages or classes using combinations of four structural elements - tree size (DBH); percent of canopy covered; number of canopy layers, and number of standing or downed dead trees – as criteria for distinguishing stand conditions and forest development stages. For presentation purposes, the classification has been summarized into seven stand development classes, based on the Carey et al. (1996) biodiversity classification.

Description of Classes	
Ecosystem initiation (EIS)	Death or removal of overstory trees by wildfire, windstorm, insects, disease, or timber harvesting leads to establishment of a young forest ecosystem.
Competitive exclusion (CE)	Trees fully occupy the site and compete with one another for light, water, nutrients, and space so that most other vegetation and many trees become suppressed and die.
Understory development (UD)	Achievement of dominance by some trees and death or removal of other trees leads to reduced competition that allows understory plants to become established. Understory of forbs, ferns, shrubs, and trees has developed after the death or removal of some dominant trees; time has been insufficient for diversification of the plant community.
Botanically diverse (BDS)	Organization and structure of the living plant community becomes complex with time, but lack of coarse woody debris, etc. precludes a full, complex biotic community.
Niche diversification (NDS)	The biotic community becomes complex as coarse woody debris, cavity trees, litter, soil organic matter and botanical diversity increase; wildlife foraging needs are met.
Fully functional (managed) (FFS)	Additional development provides habitat elements of large size and interactions that provide for the life requirements of diverse vertebrates, invertebrates, fungi and plants.
Old growth (natural) (OGN)	Forest ecosystems after more than 250 years of development uninfluenced by civilization that have achieved elements of large stature, great diversity and complex function.

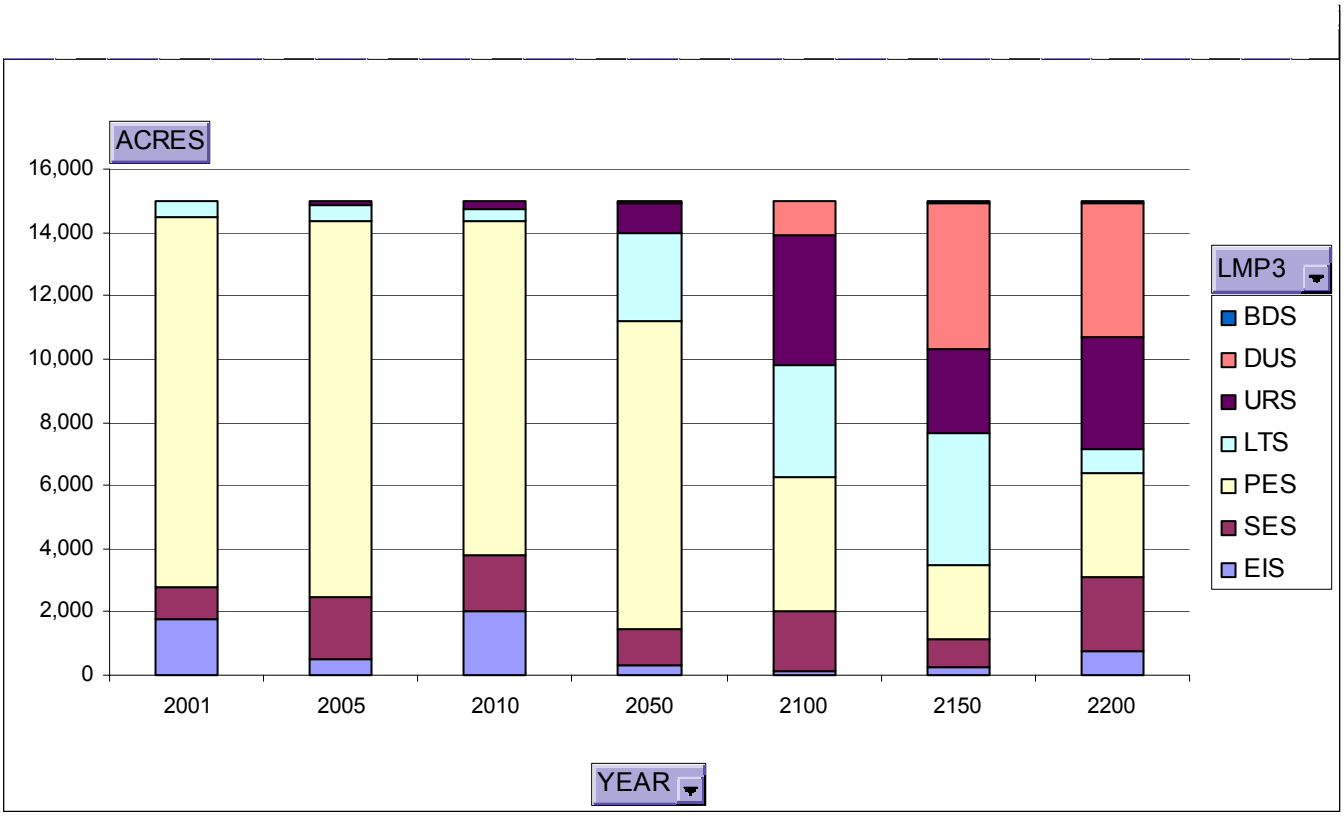
Note: Classifications of stand structure and development are arbitrary and they tend to be interpreted as a discreet set of series, rather than a continuum (Franklin et al.2002). DNR's classification is not different in these ways from other classifications. Its purpose is to provide a systematic way to evaluate and compare the Sustainable Harvest alternatives or other alternatives such as those for Lake Whatcom.

DRAFT - Subject to Change Over Time

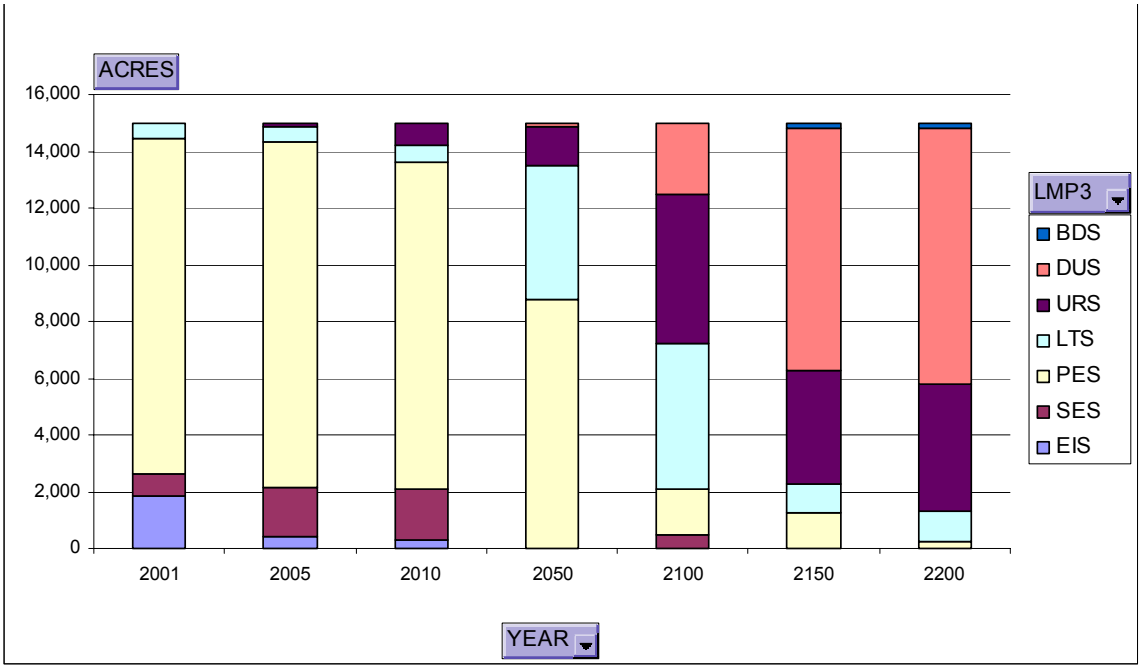
Stand Structure Analysis
Lake Whatcom DEIS Preferred Alternative



Stand Structure Analysis
Lake Whatcom DEIS No Action Alternative



Stand Structure Analysis
Lake Whatcom DEIS Alternative 3



Project Title: Measurement of mercury mobilization and accumulation in fish in response to prescribed fire in a boreal forest ecosystem

Principal Investigator(s) & Affiliation, Address, Telephone/Facsimile Number(s), & E-mail:

- Randall Kolka, Project Leader and Research Soil Scientist, Ecology and Management of Riparian and Aquatic Ecosystems, USDA Forest Service - North Central Research Station, 1831 Hwy. 169 E., Grand Rapids, MN 55744-3399 Phone: 218-326-7115, Fax: 218-326-7123, rkolka@fs.fed.us

- Trent Wickman, PE, Air Resource Specialist, Superior National Forest, 8901 Grand Avenue Place, Duluth, MN 55808 Phone: 218-626-4372, Fax: 218-626-4398, twickman@fs.fed.us

- Scott Snelson, Fisheries Biologist, Superior National Forest, 8901 Grand Avenue Place, Duluth, MN 55808 Phone: 218-626-4365, Fax: 218-626-4398, ssnelson@fs.fed.us

- Laurel Woodruff, Geologist, United States Geological Survey, 2280 Woodale Drive, Mounds View, MN, 55112 Phone: 763-783-3291, Fax: 763-783-3103, woodruff@usgs.gov

Duration of Project: three years

Annual Funding Requested from the Joint Fire Science Program: $ 164,880 (yr 1)

Total Funding Requested from the Joint Fire Science Program: $ 493,470

Total value of In-kind and Financial Contributions: $ 200,500+

Abstract

Mercury (Hg) has been identified as one of today's most important environmental contaminants. Mercury contamination in fish is well known in the Great Lake States as well as in the northeast U.S, Canada, and northern Europe, even in remote wilderness areas. Although we are beginning to understand the Hg cycle in forested systems and the important Hg species that lead to bioaccumulation in the food chain, little is known of how wildland or prescribed fire affects Hg cycling processes. In this study we will assess Hg cycling processes in both pre- and post-burned watersheds in the Boundary Waters Canoe Area located in the Superior National Forest in northeast Minnesota. The prescribed burning program on the Superior National Forest was developed in response to a major blowdown event that occurred in 1999. The study area provides a rare opportunity to study fire/ecosystem Hg interactions in a wilderness that is dominated by lakes and wetlands. We will select undeveloped lakes in both burned (10 treatment lakes) and unburned (10 control lakes) watersheds and measure total-Hg, methyl-Hg (bioaccumulative form of Hg) and other important ions in precipitation, throughfall, soil, lake water and in 1+ year fish (perch) both pre-burn and post-burn, to assess sources of Hg and determine if changes in sources alters the concentration of Hg in fish. Our hypothesis is that prescribed fire will have an effect on the watershed cycling of Hg and that it is quite conceivable to see a response in fish concentrations. The research proposed here fits well with priorities listed in task statement #2 regarding studies to address ecological, physical, or chemical effects of wildland fire. The results of our study will be critically important as federal agencies, especially the USDA Forest Service, ramp up efforts to control fuel loads across the nation. If prescribed fire enhances the watershed transport and bioaccumulation of Hg in fish, other fuel consumption techniques should be considered, especially in sensitive regions such as the boreal region where high levels of Hg in fish is already a concern.

Problem Statement

Mercury (Hg) is of great concern in the environment because it biomagnifies up the food chain in aquatic ecosystems (EPA, 2002; EPA, 2000; EPA 1997). Mercury is of special concern to residents of Minnesota and the Great Lakes region as evidenced by the advisories on fish consumption issued in Minnesota (MPCA, 2002) and the Lake Superior Binational Program's stated goal of virtual elimination of Hg from the Lake Superior environment. Within Minnesota, the highest Hg levels in fish are found in the northeast (Kaiser et. al. 1996).

Mercury is transported through the environment along a myriad of biological, chemical, and physical pathways and has numerous chemical species. From a review of current research, three processes are clearly necessary to cause Hg to accumulate in fish. First, Hg must either be present in soils or bedrock, or be brought into an area through atmospheric deposition. Second, Hg present in a watershed must be transported to a location where methylation can take place. The methylated form of Hg is the species that is capable of bioaccumulation in the food chain. The methylation process is mediated by bacteria residing in oxygen deficient conditions (low redox conditions) such as those found in wetland soils or lake sediments (St. Louis et al., 1994). Transport of Hg could be a result of erosional processes but, in forested systems, is more likely transported by subsurface or groundwater flows (Kolka et al., 2001). Third, this methylated Hg must be delivered to a lake ecosystem where it can bioaccumulate in the food chain. Again, this transport in forested systems is generally by subsurface or groundwater flow or by direct deposition to the lake. The Hg cycle is a subject of intense research but little is known about how wildland fire affects this cycle. Wildland fires can cause exposed soils and erosional processes may become important as a transport mechanism for Hg.

In our study we will investigate how prescribed fire affects these transport processes and determine if fire can cause Hg levels in fish to increase. We expect that in response to a fire event, a proportion of the Hg held in surface layers of upland soils will be volatilized into the atmosphere and likely lost from the local system. A second proportion of Hg will be present in ash that is deposited to the lake surface. A third proportion of Hg will be present in ash and remain onsite becoming available to be either transported through surface runoff (erosional events) or more easily leached and transported by subsurface flow. If this Hg is transported to a site where methylation can take place, and then on to a lake, we believe that the fish in these downstream lakes will show elevated Hg concentrations.

The study will take place in the Boundary Waters Canoe Area (BWCA) in the Superior National Forest (SNF). The burning program on the SNF was developed in response to a major blowdown event in July, 1999. About 75,000 of the 1.1 million acres of the BWCAW will be burned over the next 5 to 7 years providing a rare opportunity to study fire/ecosystem Hg interactions in a wilderness that is dominated by lakes and wetlands.

We will select undeveloped lakes in both burned (10 treatment lakes) and unburned (10 control lakes) watersheds in and near the BWCAW. We will collect precipitation, throughfall, soil and lake water chemistry data (including Hg) and Hg in 1+ year fish (perch) from these lakes both pre-burn and post -burn, to assess sources of Hg and determine if changes in sources alters the concentration of Hg in fish.

This will be a highly collaborative effort. The USDA FS (both research and national forests), the US Geological Survey, Minnesota Department of Agriculture, and the University of Minnesota will be involved in different aspects of the study. We will also have considerable additional information available from the existing fire effects monitoring program that is a part of the burning program. In addition, there is a considerable quantity of work that has been done on mercury in this geographic area that can be used to help in the interpretation of our data (Behling, 2001; Kolka et al., 2001; Kolka et al., 1999a; Kolka et al., 1999b; Engstrom and Swain, 1997; Glass, 1991).

We anticipate quantifying the effects of prescribed fire on Hg mobilization in a boreal forest watershed, determining if a change in fish Hg concentration occurs, and suggesting mitigation measures (e.g. burn prescriptions, or rehabilitation) to lessen the effect. It may be that the effects cannot be mitigated to prevent exposure to the public, which could make site-specific fish consumption advisories necessary after burns.

Agency administrator (line officer) signature, title and telephone number: Jim Sanders, Superior National Forest Supervisor, 218-626-4302.

Introduction

Project Justification

Mercury (Hg) has been identified as one of today's most important environmental contaminants. Mercury contamination in fish is well known in the Great Lake States as well as in the northeast U.S., Canada, and northern Europe, even in remote wilderness areas. There are widespread fish consumption advisories in 26 states (including Minnesota), Canada, and Sweden (Glass et al., 1991). Health risks are presumed to be high for people that consume large quantities of fish in these regions. The most susceptible group is prenatal children, followed by young children and women. Other animals are also at health risk due to mercury contamination. Hg is implicated in reproductive problems in eagles, otters, mink and other fish-eating animals in the Great Lakes region, and in panther deaths and highly elevated levels of Hg in alligators, bald eagles and raccoons in Florida (Douglas, 1991).

Although we are beginning to understand the cycling of total-Hg and methyl-Hg (bioaccumulative form) in forested watersheds (e.g. Hintelmann et al., 2002; Kolka et al., 1999b), little work has been done understanding the role of wildland fire in Hg cycling. A recent Hg cycling review did not even address fire as a possible source of atmospherically deposited Hg (Grigal, 2002). To our knowledge, only two groups of researchers are addressing the issue of forest fire as a possible source of Hg to aquatic systems.

Hans Friedli and colleagues at the National Center for Atmospheric Research in Boulder, CO have recently published a laboratory paper assessing the Hg released to the atmosphere following the burning of different types of fuel (Friedli et al., 2001). According to their laboratory studies, nearly 100% of Hg stored in fuels was emitted to the atmosphere with 95% of that emitted as elemental Hg and particulate Hg accounting for the remainder. Newly released elemental Hg enters the global cycle and undergoes chemical transformations in the atmosphere before being redeposited. The Hg we are concerned with in this proposal is the remaining 5% that is emitted as particulate Hg and has the potential to be deposited locally during a fire event. Also, it is important to remember the study done by Friedli et al. (2001) was conducted in a controlled laboratory environment. Actual fires may potentially emit considerably more particulate Hg.

A second group of researchers at the University of Montreal have conducted experiments assessing Hg concentrations in the aquatic food chain in undisturbed, burned and logged watersheds in central Quebec (Garcia and Carignan, 2000; Garcia and Carignan, 1999). They found that in lakes where the watershed was burned, there was no difference in zooplankton or northern pike (*Esox lucius*) Hg concentrations when compared to lakes in undisturbed watersheds. One drawback of these studies is that data was only collected post-burn and high natural variability in zooplankton and northern pike Hg concentrations could have led to greater uncertainty in their statistics. The mean Hg concentration in northern pike taken from burned lakes (3.0 ug g^{-1}) was considerably higher than those taken from lakes in undisturbed watersheds (1.9 ug g^{-1}), but again, not statistically significant.

It is clear from a review of the literature that more investigation needs to be conducted assessing the impact of wildfire or prescribed fire on the Hg cycle and the potential implications on aquatic biota. Our proposal addresses this important gap in our knowledge and fits well within priorities listed in task statement #2 regarding studies to address ecological, physical, or chemical effects of wildland fire. Unlike the Friedli et al. (2001) study, our study will be conducted in the field with actual prescribed fires. Also, unlike the Garcia and Carignan (2000; 1999) studies, we will measure our variables both pre- and post-burn which should lead to much greater statistical control. The results of our study will be critically important as federal agencies, especially the USDA Forest Service, ramp up efforts to control fuel loads across the nation. If prescribed fire enhances the watershed transport and bioaccumulation of Hg in fish, other fuel consumption techniques should be considered, especially in sensitive regions such as the boreal region where high levels of Hg in fish is already a concern.

Project Objectives

The primary objective of our research is to determine if prescribed fire can cause elevated levels of Hg in fish. Embedded within the primary objective is to develop an understanding of the main pathways by which Hg is entering the aquatic system during a fire. We anticipate at least four peer-reviewed publications to result from our research. One publication will address that effect fire has on soil Hg. A second will address the effect that fire has on Hg deposition. A third will address the effect that fire has on fish Hg concentrations. A final publication will be brought together integrating all aspects of the study.

If indeed prescribed fire has a deleterious effect on fish Hg concentrations, alternative fuel reduction strategies should be considered. Alternatively, a management program for fish consumption advisories could be established following

fires. If the null hypothesis is true and prescribed fire has no effect on fish Hg concentrations, we can cross Hg of the list of potential negative impacts of prescribed burning programs.

Background

In general, Hg in terrestrial and aquatic systems is derived from the atmosphere in the form of wet and dry deposition. Mercury (Hg^{2+}) becomes volatile upon reduction to elemental mercury (Hg^0), enabling it to enter the atmosphere. Hg^0 comprises approximately 99% of the total gaseous Hg in the atmosphere (Fitzgerald et al., 1991). Particulate Hg enters the atmosphere as complexes with the divalent form of Hg (Hg^{2+}). There are a variety of sources of Hg, both natural and anthropogenic. Hg is a trace element in geologic materials which is released upon weathering of these materials (a very slow process). Hg from geologic materials therefore imparts very little to the local or regional inventory unless in an area of elevated concentration (Barghigiani and Ristori 1994). Natural sources of Hg also include those wherein natural gases are expelled into the atmosphere. Cataclysmic events such as volcanic eruptions and forest fires expel considerable natural gases and particulates, including Hg. A more subtle gaseous input is that occurring continually during the decomposition of organic matter from terrestrial and aquatic systems. It can be argued that Hg emissions from both forest fires and the decomposition of organic matter are, at least in part, anthropogenic because Hg in vegetation and organic matter is likely derived from past anthropogenic emissions. Because Hg^0 is nearly insoluble in water, the major input of Hg to the earth's surface is via wet and dry deposition of Hg^{2+} compounds, most notably as rain scavenged particulates and as soluble complexes with Cl^-, OH^-, and SO_3^{2-}. A small fraction of the total deposition (0-7%) occurs as methyl-Hg, the bioaccumulative form of Hg (St. Louis et al., 1994; Fitzgerald et al., 1991).

Formation of the bioaccumulative methyl-Hg is enhanced by low redox status (low O_2 conditions such as those found in wetlands and lake sediments) (Watras et al., 1995), low pH (Bloom et al., 1991) and increases in temperature (Matilainen et al., 1991). Both abiotic and biotic methylation have been proposed for mechanisms governing methyl-Hg production, however, it appears that microbial methylation is the most important origin of methyl-Hg in aquatic systems (Kelly et al., 1995). It also appears that populations of sulfate-reducing bacteria play an important role in Hg methylation (Matilainen, 1995; Watras et al., 1995).

Major studies have been carried out investigating Hg cycling in aquatic (e.g. St. Louis et al. 1994) and terrestrial environments (e.g. Kolka et al., 1999b). It is widely recognized that terrestrial transport is important in determining the ultimate fate of atmospherically-deposited Hg with respect to the aquatic environment (Lindqvist 1991). In the typical watershed, the majority of atmospheric Hg deposition occurs on terrestrial landscapes due to (a) the higher areal proportion of land to surface water in most regions, and (b) to the higher rates of dry deposition associated with vegetated landscapes. Studies in Minnesota and adjacent areas indicate that about 25% of atmospheric Hg deposited on terrestrial basins reaches the associated lakes (Swain et al. 1992), and contributes between 6 and 62% of the total Hg loading of these lakes (the exact proportion depends on the terrestrial to lake surface area ratio and on the presence of peatlands in the watershed) (Krabbenhoft et al. 1995; Henning et al. 1989).

Although we are beginning to understand the total-Hg and methyl-Hg cycles in forested watersheds, little research has been conducted addressing the influence of forest fire on Hg cycling. We conducted a thorough review of the literature and were only able to find three published papers by two groups of researchers that even remotely addressed the influence of forest fire on Hg cycling. Researchers at the National Center for Atmospheric Research in Boulder, CO conducted a laboratory study assessing Hg emitted from different types of fuels (Friedli et al., 2001). Fuels included numerous types of litter (both conifer and deciduous) and live vegetation. Independent of fuel type, nearly 100% of Hg stored in fuels was emitted to the atmosphere with 95% of that emitted as elemental Hg (Hg^0) and particulate Hg accounting for the remainder. The authors admit in the paper that the low percentage of Hg in particulate form was somewhat unexpected. We think that actual fires may potentially emit considerably more particulate Hg. Friedli and his colleagues are currently expanding their work to assess Hg concentrations in air during actual fires (Friedli, personnel communication).

A second group of researchers at the University of Montreal have conducted experiments assessing Hg concentrations in the aquatic food chain in undisturbed, burned and logged watersheds in central Quebec (Garcia and Carignan, 2000; Garcia and Carignan, 1999). They found that in lakes where the watershed was burned, there was no difference in zooplankton or northern pike Hg concentrations when compared to lakes in undisturbed watersheds. The mean Hg concentration in northern pike taken from burned lakes (3.0 ug g^{-1}) was considerably higher than those taken from lakes in undisturbed watersheds (1.9 ug g^{-1}), but again, not statistically significant. A major drawback of these studies is that data was only collected post-burn. High natural variability exists in northern pike (7 fold) Hg concentrations in their study, similar

to that of many other fish studies (e.g. Greenfield et al., 2001). Without pre-burn data their statistical analysis is simply a post-hoc comparison that includes considerable variability associated with factors that the researchers could not control. A more powerful test would be to compare changes in fish Hg concentration from pre- to post-burn. The variability in the amount of change is likely to be much smaller than that from the fish Hg concentrations.

In the study proposed here, we will collect both pre- and post-burn data. We propose to not only test the effect of prescribed burning on fish Hg concentration but also to begin to assess sources of Hg during a burn. We will select undeveloped lakes in both burned (10 treatment lakes) and unburned (10 control lakes) watersheds in and near the Boundary Waters Canoe Area in northeastern Minnesota. We will collect precipitation, throughfall, soil and lake water chemistry data (including Hg) and Hg in 1+ year fish (perch) from these lakes both pre- and post-burn, to assess sources of Hg and determine if changes in sources alters the concentration of Hg in fish. Our hypothesis is that prescribed burning will initially decrease Hg concentrations in soil (including forest floor), slightly increase Hg in precipitation, increase Hg in throughfall (especially during the burn), increase lake concentration of Hg and finally increase concentration in fish. We would also expect that these initial increases and decreases would lessen over time since a burn. A fundamental assumption in our study is that if total-Hg increases (e.g. in lake water) we will also see increases in methyl-Hg. Because the methylation process is biologically mediated, we are assuming that total-Hg is limiting in these lake systems and that an increase in total-Hg will result in increases in methyl-Hg. We are confident in this assumption because where Hg spills have occurred higher concentrations are found in the aquatic food chain.

Materials and Methods

Research Sites and General Study Design

The study will be conducted in the Boundary Waters Canoe Area (BWCA) located in the Superior National Forest in northeast Minnesota. The BWCA is designated as a wilderness area with no motorized traffic. In July of 1999, a major blowdown event occurred. Because of the considerable fuel loadings resulting from the blowdown, an aggressive burning program was developed by the Superior National Forest. About 30,000 of the 400,000 ha of the BWCA will be burned over the next 5 to 7 years providing a rare opportunity to study fire/ecosystem Hg interactions in a wilderness that is dominated by lakes.

An existing database housed by the Superior National Forest contains Hg in fish data collected since 1987. Not surprisingly, fish Hg concentration varies considerably across the BWCA. Nonetheless, we have a considerable database in place to assist us in choosing sites. From the database, we have selected 40 lakes greater than 100 ha to be candidates in the study, 20 lakes that are in watersheds containing burn units and 20 lakes where their watersheds are outside of burn units. Within each subset of 20 lakes, we have selected 10 lakes with relatively high Hg in fish and 10 lakes with relatively low Hg in fish. Of the 40 candidate lakes, 20 lakes will ultimately be chosen for the study. The final study design will include 10 treatment lakes (within a burn area) and 10 control lakes (outside of a burn area). Within the 10 treatment lakes and 10 control lakes we will also stratify by fish Hg concentration. Five lakes will have relatively high Hg in fish and five lakes will have relatively low Hg in fish. Our design is a 2 (burn vs. unburned) X 2 (high Hg fish vs. low Hg fish) factorial with five replicates. If funded, candidate lakes will be visited and assessed. An important determining variable for exclusion or inclusion will be access. Because the BWCA has no motorized access, some of these remote lakes will likely be difficult and time consuming to sample.

Soil Sampling and Analysis

The total number of forest floor sampling sites in each watershed will be determined by the distribution of fuel and soil types. Only upland forest soils will be sampled. Sampling protocols are refined from previous unpublished research by P.I. Woodruff in Voyageurs and Isle Royale National Parks that have similar geologic and landscape characteristics. Within a watershed a minimum of 5 sample sites will be established, with replicate samples taken from each fuel/soil type within the watershed. Sites within the burned watersheds will be accurately located and resampled following fire. At each individual site volumetric samples will be collected to calculate the elemental load per unit area. Three samples will be collected from a 1 m x 1 m square: 1) forest litter plus O-horizon, 2) mineral soil from 0-5 cm depth, and 3) mineral soil from 5-10 cm depth.

Samples will be weighed and sieved at the sampling site. Samples will be reweighed when air-dry. Representative samples will be submitted for geochemical analysis through the U.S. Geological Survey. All organic samples will be milled, with a split set aside for mercury analysis by cold vapor atomic absorption spectrophotometry (CV-AAS). The remainder of the organic samples will be ashed at 500 °C and analyzed for 42 elements by inductively coupled plasma mass

spectrometry as well as arsenic and selenium by AAS. Mineral soils will be analyzed for 42 elements by a combination of inductively coupled plasma-atomic emission spectrometry and mass spectrometry (ICP-AES-MS) under USGS contract to XRAL Laboratories, Toronto, Canada, in addition to analyses for organic carbon, mercury, arsenic, and selenium.

In burned watersheds, ash and charcoal samples will be collected from the surface as soil sample sites as soon as possible following fire. These samples will be mixed with deionized water (1:5). The resultant ash leachate solution will be analyzed for mercury by CV-AAS, for 44 by elements for ICP-MS, and for fluoride, sulfate, chloride and nitrate by ion chromatography.

Precipitation and Throughfall Sampling and Analysis

Sampling for Hg in natural waters requires established clean techniques because of the low-levels (ng to pg L^{-1} range) of Hg in the environment. Although concentrations are low, they are environmentally important. The P.I. Kolka is very familiar with these techniques and will assure that proper sampling and handling techniques are followed. Open, wet-only precipitation will be measured for total-Hg, methyl-Hg, pH, alkalinity, cations, anions and total organic carbon in a centrally located site associated with National Atmospheric Deposition Program (NADP). The NADP site is sampled on a weekly basis. Analysis for total-Hg and methyl-Hg will be conducted with cold vapor atomic fluorescence spectroscopy. Bulk precipitation will be measured on the lakes themselves with precipitation collectors developed by the P.I. Kolka (Kolka et al., 1999a). A bulk precipitation collector will be placed on each lake and sampled monthly during the snow-free season. Analysis of bulk precipitation will be identical to open, wet-only precipitation collected at the NADP site.

Throughfall will not be collected in each of the study watersheds. Instead we will locate 20 throughfall collectors based on canopy type and treatment. Ten throughfall collectors will be placed in burned watersheds and 10 collectors in unburned watersheds. Within the ten throughfall collectors located in burned and unburned watersheds, five collectors will be placed in coniferous sites and five will be placed in deciduous sites. Previous research by the P.I. Kolka indicated significant differences in throughfall deposition between conifer and deciduous canopy types (Kolka et al., 1999a). Throughfall collectors will be similar in design to the bulk collectors located on lakes. Throughfall will be analyzed for the same parameters listed above for bulk precipitation. Total and methyl-Hg in bulk precipitation and throughfall will be measured at the University of Minnesota in the Department of Soil, Water and Climate. All other analysis will be conducted at the USDA Forest Service's lab in Grand Rapids, MN.

Lake Water Sampling and Analysis

A lake water sampling site will be established on each of the 20 lakes. Lakes will be sampled monthly during the snow-free period. The literature indicates that considerable chemistry differences can occur by depth, especially in lakes that stratify in the summer (Horne and Goldman, 1994). Because of possible chemistry differences by depth in our lakes, sampling will conducted at two depths, one near the surface in the epilimnion and a second near the lake bottom in the hypolimnion. Like the sampling of precipitation and throughfall, clean techniques will be employed during lake sampling, transport and analysis. Lake water will be analyzed for identical parameters and with the same techniques as those for bulk precipitation and throughfall.

Fish Sampling and Analysis

Fish sampling will be conducted annually on the 20 study lakes. We will use netting, electroshocking and hook and line (if necessary) to sample 10 year 1+ yellow perch (*Perca flavescens*) during each sampling. Because of its' abundance, yellow perch has been commonly used as the test species in Hg studies (e.g. Greenfield et al., 2001). Fish body condition, length, weight and age will measured. Length to age relationships for each lake will determined using scale, vertebrae, and otolith analyses from a subsample of the fish collected. Fish will be handled with gloved hands, stored in Ziploc bags, kept cool in the field and frozen until analyzed. The mercury content of the fish will be determined by the Minnesota Department of Agriculture using EPA Method 7473 - "Mercury in Solids and Solutions by Thermal Decomposition Amalgamation and Atomic Absorption Spectrophotometry".

Prescribed Burn Data

The crews on the Superior National Forest collect numerous types of data before, during and after the burns. Data collected on the severity of the burn, amount of fuel consumed, changes in forest floor depth, upland and riparian vegetation changes and some additional lake water chemistry sampling will be available to the PIs in this project. The prescribed burn data will not only be good support information for our studies but may also be valuable when we scale up our results.

Statistical Analysis

Major effects between treatment and control lakes will be tested through an analysis of variance (ANOVA). ANOVA tests will be performed on pre-burn data, post-burn data and on changes between pre- and post-burn data. Nonparametric tests such as a Kruskal-Wallis test may also be necessary if data is not normally distributed. Regression will be used to assess relationships between total-Hg, methyl-Hg and other chemical parameters in soils, wet-only precipitation, bulk precipitation, throughfall, lake water, and fish.

Expected Results

We expect that fish Hg concentrations will increase in lakes where burns occurred in the watershed. Increases may be the result of increased direct deposition to the lake or possibly from more mobile forms of Hg resulting from the burn (i.e. through leaching or erosion). Through our soil analysis we will estimate how much Hg is being emitted from the burned watersheds. Our centrally located wet-only NADP collector will allow us to determine what the "background" or normal deposition of Hg should be for these watersheds. Our bulk collectors on the lakes will help us determine if elevated deposition is occurring to the lakes. Throughfall collection will indicate how much of the newly evolved particulate Hg is being trapped as dry deposition by vegetation within the watershed. Particulate deposition captured in throughfall may be a continuing source of Hg following a burn. Direct analysis of lake water will determine if prescribed fire leads to greater lake water concentrations. Finally, if lake water concentrations of Hg increase (especially methyl-Hg), the analysis of fish will determine if the higher lake water concentrations are leading to higher fish concentrations. By the end of the study we will have a thorough understanding of the effects that prescribe fire has on soil Hg, deposition of Hg and those implications on aquatic biota.

Project Duration and Timeline

We are asking for the maximum three years of funding. We believe that a minimum of three years is necessary to monitor the sites both pre-burn and post-burn. We believe it will take a minimum of 1 year post-burn for the effects to be seen. In addition it is impossible to predict exactly when individual burn units will be lit due to weather and other constraints beyond our control. Our timeline is as follows:

Summer 2003
Select treatment and control lakes
Build bulk precipitation and throughfall collectors

Fall 2003
Installation of bulk precipitation and throughfall collectors
Begin sampling of precipitation, throughfall, and lake water

Spring, Summer, Fall 2004
Sample precipitation, throughfall, and lake water
Initial pre-burn sampling of soils
Initial pre-burn sampling of fish

Winter 2004-2005
Analyze pre-burn data

Spring 2005
Treatment watersheds burned
Post-burn soil sampling

Spring, Summer, Fall 2005
Sample precipitation, throughfall, and lake water
Post-burn fish sampling

Winter 2005-2006
Analyze post-burn data

Spring 2006
Sample precipitation, throughfall, and lake water
Final post-burn soil sampling
Final post-burn fish sampling

Summer 2006
Analyze 2nd year of post-burn data
Develop manuscripts

Collaboration and Responsibilities

The PI Kolka will be responsible for the overall project and he will assure that timelines and project objectives are met. He will also be responsible for bulk precipitation and throughfall collector design and water analyses. He will

collaborate with Dr. Edward Nater, Chair of the Department of Soil, Water and Climate at the University of Minnesota for Hg analysis. Drs. Kolka and Nater will also advise the Ph.D. student.

The PI Wickman will be responsible for activities conducted by the Superior National Forest. The Superior National Forest will be responsible for much of the collection of bulk precipitation, throughfall and lake water. He will also assist PI Snelson in the fish collection. PI Wickman is certified to be on the prescribed burns and will be present to sample just prior to and after burns.

The PI Snelson will mainly be responsible for the fish collection and will assist in other samplings as necessary.

The PI Woodruff will be responsible for the soil sampling and analysis. Dr. Woodruff will collaborate with Dr. William Cannon, Research Geologist with U.S. Geological Survey in Reston, VA to analyze the soil data and develop publications.

Deliverables

Annual progress reports will be prepared within 6 months after every 12 months from the date funding was initially received. As discussed in the *Objectives*, we expect a minimum of 4 peer-reviewed papers resulting from the research. One publication will address that effect fire has on soil Hg. A second will address the effect that fire has on Hg deposition. A third will address the effect that fire has on fish Hg concentrations. A final publication will be brought together integrating all aspects of the study.

Technology Transfer

Our progress reports and peer-reviewed publications will serve as one vehicle to transfer the results of this study. Presentations will be made a regional and national meetings to further disseminate our results. The USDA Forest Service Superior National Forest and North Central Research Station will jointly develop a website dedicated to the project. Both the National Forest and Research Station have employees with considerable expertise in web site development. We anticipate that the website will include maps and pictures of sites, descriptions of the various studies and links to reports and publications that result from the study. Finally, we would expect one or more management guides to result that will be distilled from our peer-reviewed publications.

DEIS Appendix D: Tribal Cultural Resources

Type of Use Historic (H) or Current Use (CU)	***Size of Site(s)***	***Fixed or Move Over Time***	***Number of known sites in planning area (only Lummi Nation data has been used).***	***Private (P) or State (S) Land***	***Protection Needs—Distance requirements consistent with the Lummi Nation Cultural Management Plan*** ***Note—Federal Laws may apply including National Historic Preservation Act and Historic and Archaeological Data Preservation Act, etc. Relevant State Laws are found within the matrix.***	***Comments/ Recommendations*** ***See Purity, Privacy, Isolation and Permanence discussion in PDEIS text***
Ritual Bathing H/CU	Site & water-shed above site	Fixed within reach of a stream that may meander	8 sites identified, others may be present	P, S	**Purity**- stable streambed w/ cool, clear water. No human activities in watershed above bathing sites that would impact water quality or purity, privacy, and isolation. **Privacy**- visual screening from other human activity; no entry (300' buffer), or whatever is necessary to ensure line of sight privacy. **Isolation**- at least ¼ mile from active roads (300' buffer) or whatever is necessary to ensure isolation. **Permanence**-long-term site protection needed.	Location can change as a result of natural processes such as stream meanders--should not change due to human activities. Each location may have a specific local "spirit." Water quality & quantity, and sediment buildup issues Some families and individuals have bathing areas that they will not divulge to tribe or any outside entity. Buffer needs to be evaluated on a site-specific basis to ensure visual screening.
Archaeolog-ical Sites— H	< 25 acres	Fixed	Unknown	P, S	RCW 27.53--Archaeological Sites and Resources Protection plans based specific to each site based on proposed activities and unique characteristics.	45WH88 is the site number assigned by Office of Archaeology and Historic Preservation. Identify and record sites in compliance with DNR policy PO06-001.
Culturally Modified Trees (CMTs): **<u>Known</u>** H/CU **<u>Possible</u>** H/CU	 320 acres 5-80	 Fixed	 1 Unknown	S P, S	**Privacy**- visual screening from other human activity; no entry 100' buffer) or whatever is necessary to ensure line of sight privacy. **Isolation**- at least 200' from active roads and from slope break, or	Can include historic trees. For example, in Section 18, T 37N, R 4E, is a stump with springboard notches w/1895 date carved into it. A hatchet is also present. Record sites with OAHP and develop MOU (Agreement with

Type of Use Historic (H) or Current Use (CU)	*Size of Site(s)*	*Fixed or Move Over Time*	*Number of known sites in planning area (only Lummi Nation data has been used).*	*Private (P) or State (S) Land*	*Protection Needs—Distance requirements consistent with the Lummi Nation Cultural Management Plan* *Note—Federal Laws may apply including National Historic Preservation Act and Historic and Archaeological Data Preservation Act, etc. Relevant State Laws are found within the matrix.*	*Comments/ Recommendations* *See Purity, Privacy, Isolation and Permanence discussion in PDEIS text*
	acres				whatever is necessary to ensure isolation. **Permanence**- Buffer for windthrows and sunscald 200" around groves. RCW 27.53 Archaeological Sites and Resources Protection plans based specific to each site based on proposed activities and unique characteristics. Any harvest activities should fall and yard away from buffers.	Gifford Pinchot is model). See comments under Hunting and Gathering.
Spirit Quest Sites and Traditional Song Places H/CU	1,280 acres	Fixed	6 sites	P, S	**Privacy**- visual screening from other human activity; no entry 100' buffer or whatever is necessary to ensure line of sight privacy. **Isolation**- at least ¼ mile from active roads and a 100' no entry buffer or whatever is necessary to ensure isolation.	Any harvest activities fall and yard away from buffers. No entry zone
Traditional Named Places H		Fixed	7 areas	P, S	Site-specific consultation required.	
Hunting and Gathering Sites (H&G) H/CU	Entire Planning Area	Fixed within Area 417 for Lummi Nation For Nooksack	Unknown	P, S	Access needs No chemicals, herbicides, pesticides application without consultation (consult w/tribe on current use areas).	Access Issues include physical access, access to variety of necessary species, and access to non-contaminated species. Provide access consistent with Article 5 of the Point Elliot Treaty. Implement Forest Plan Special Lands Policies 13, 14.

Type of Use Historic (H) or Current Use (CU)	*Size of Site(s)*	*Fixed or Move Over Time*	*Number of known sites in planning area (only Lummi Nation data has been used).*	*Private (P) or State (S) Land*	*Protection Needs—Distance requirements consistent with the Lummi Nation Cultural Management Plan* *Note—Federal Laws may apply including National Historic Preservation Act and Historic and Archaeological Data Preservation Act, etc. Relevant State Laws are found within the matrix.*	*Comments/ Recommendations* *See Purity, Privacy, Isolation and Permanence discussion in PDEIS text*
		Within those areas can move in response to natural processes.				Develop access MOU similar to that developed by Mt. Rainier NPS and Nisqually Tribe and Draft Lummi Nation MOA with Whatcom County and National Park Service. Investigate and evaluate.
Ceremonial Flora/ Medicine Sites H/CU	See H&G above	See H&G above	Unknown	P, S	See H&G above	See H&G above Downed woody debris source of paint. See comments under Hunting and Gathering above.
Gear Storage Sites H/CU	5 acres (includes buffer)	Fixed	Unknown	P, S	**Privacy**- visual screening from other human activity; no entry within 300' buffer or whatever is necessary to ensure privacy. **Isolation**- at least 300' from active roads or whatever is necessary to ensure isolation. **Permanence**- Long-term protection, buffer for windthrow of 50'.	Snags evidence of Old Growth Forest and also used for gear storage. For harvest activities fall and yard away from buffer.
Caves H	5 acres (includes buffer)	Fixed	1	S	**Privacy**- visual screening from other human activity; No entry within 300' buffer radius. **Isolation**- at least ¼ mile from active roads (250' buffer from cave mouth). **Permanence**- Long-term protection Implement HCP Section IV-F, pp. 153-154)	Coincident w/Petroglyph; coincident w/village sites—see also archaeological sites Other cave sites may occur in planning area.
Burials—	Unkno	Fixed	Unknown,	P, S	RCW 27.44 Indian	Known burial in Blue Canyon

Type of Use Historic (H) or Current Use (CU)	*Size of Site(s)*	*Fixed or Move Over Time*	*Number of known sites in planning area (only Lummi Nation data has been used).*	*Private (P) or State (S) Land*	*Protection Needs—Distance requirements consistent with the Lummi Nation Cultural Management Plan* *Note—Federal Laws may apply including National Historic Preservation Act and Historic and Archaeological Data Preservation Act, etc. Relevant State Laws are found within the matrix.*	*Comments/ Recommendations* *See Purity, Privacy, Isolation and Permanence discussion in PDEIS text*
divisible into cairns and tree burials H	wn				Graves and Records RCW 27.53 Archaeological Sites and Resources	area.
Trails H/CU	Trail	Fixed	3	P, S	RCW 27.53 Archaeological Sites and Resources Protection plans based specific to each site based on proposed activities and unique characteristics	Protection plans for trails usually the same as for limited harvest along riparian zones—i.e. limit number of crossings etc.
Petroglyphs H	Boulder Rock Face	Fixed	4 historic 3 current use 1 recorded -- 45WH88 Austin Creek 1 desecrated.	P, S	RCW 27.44 Indian Graves and Records RCW 27.53 Archaeological Sites and Resources Long-term protection needed. Protection plans based specific to each site based on proposed activities and unique characteristics	Recorded petroglyph is coincident with cave —see also archaeological sites. Petroglyphs often coincident with village sites 45WH88 is site number assigned by Office of Archaeology and Historic Preservation.
Old Growth H/CU				P, S	Implement Large Structurally Unique Trees and Snags Recommendations of the HCP F- IV pp. 156-157.	Implement Forest Plan Special Lands Policies 13, 14 and Special Forest Products Policy No. 8
Wildlife H/CU				P, S		Provide access consistent with Article 5 of the Point Elliot Treaty.
Fish H/CU				P, S		Provide access consistent with Article 5 of the Point Elliot Treaty.

Type of Use Historic (H) or Current Use (CU)	*Size of Site(s)*	*Fixed or Move Over Time*	*Number of known sites in planning area (only Lummi Nation data has been used).*	*Private (P) or State (S) Land*	*Protection Needs— Distance requirements consistent with the Lummi Nation Cultural Management Plan* *Note—Federal Laws may apply including National Historic Preservation Act and Historic and Archaeological Data Preservation Act, etc. Relevant State Laws are found within the matrix.*	*Comments/ Recommendations* *See Purity, Privacy, Isolation and Permanence discussion in PDEIS text*
Totems/ Canoes H	20 acres	Fixed	1	P	RCW 27.53 Archaeological Sites and Resources No entry	Investigate and evaluate. Seek permission of landowner to record site.

HISTORIC CULTURAL RESOURCES							
Type of Use *Historic (H) or Current Use (CU)*	*Size of Site(s)*	*Fixed or Move Over Time*	*Physical Descrip-tion of site or use area*	*Number of known sites in planning area (only Lummi Nation data has been used).*	*Private (P) or State (S) Land*	*Protection Needs Note—Federal Laws may apply to these cultural resources, including National Historic Preservation Act and Historic and Archaeological Data Preservation Act, etc. Relevant State Laws are found within the matrix.*	*Comments/ Recommendations*
Historical Archaeolo-gical Sites— H	< 25 acres	Fixed	Varied	Unknown	P S	RCW 27.53 Archaeological Sites and Resources Protection plans based specific to each site based on proposed activities and unique characteristics	Identify and record sites in compliance with DNR policy PO06-001 Bed of the Bellingham Bay and Eastern RR recorded at OAHP Physical remains of historic activities. For example, 34 Homesteads recorded on GLO notes may have left archaeological remains

Historic Buildings/ Structures	< 5 acres	Fixed		1	P		Park Store/Town Hall
Shipwrecks	< 5 acres	Fixed	Bed of Lake Whatcom	5	S	RCW 27.53 Archaeological Sites and Resources Protection plans based specific to each site based on proposed activities and unique characteristics	State owned aquatic lands

Bibliography for DEIS

DNR analysts considered the following new sources in preparing work for the Lake Whatcom DEIS released September 8, 2003:

Carbon Sequestration:

Bowyer, J., D. Briggs, B. Lippke, J. Perez-Garcia, and J. Wilson. 2002. Life cycle environmental performance of renewable materials in the context of residential building construction. Consortium for Research on Renewable Industrial Materials (CORRIM). Phase I Interim Research Report. www.corrim.org accessed on 4/21/03.

Cohen, W.B., M.E. Harmon, D.O. Wallin, and M. Fiorella. 1996. Two decades of carbon flux from forests of the Pacific Northwest. Estimates from a new modeling strategy. Bioscience 46(11): 836-44.

Harmon, M.E., W.K. Ferrell, and J.F. Franklin. 1990. Effects on carbon storage of conversion of old-growth forests to young forests. Science 247: 699-702.

Water and water-related topics

Collins, B. D. and G. R. Pess. 1997. Critique of Washington's watershed analysis program. Journal of the American Water Resources Association, 33 (5), p. 997-1010.

King, J. E. 1966. Site index curves for Douglas-fir in the Pacific Northwest. Weyerhaeuser Forestry Paper, Weyerhaeuser Company. Centralia, WA

Reid, L. M. 1998. Review of Pacific Lumber Company SYP/HCP. USDA Forest Service. Pacific Southwest Research Station, Arcata, CA. 62 p.

Wildlife and habitat::

DNR Forestry Handbook

Bury, R.B. and Corn, P.S. 1988. Responses of aquatic and streamside amphibians to timber harvest; a review. In: K.J. Raedeke (Editor), Streamside Management: Riparian Wildlife and Forestry Interactions. Proc. Symp., 11-13 February, 1987, Univ. of Washington, Seattle. Institutue of Forest Resources, Univ. Washington, Contrib. 59, pp. 165-181.

Corn, P.S. 1989. Logging in Western Oregon: Responses of headwater habitats and stream amphibians. Forestry Ecology and Management 29:39-57.

Croonquist, M.J., and R.P. Brooks. 1993. Effects of habitat disturbance on bird communities in riparian corridors. J.Soil and Water Cons. 48(1):65-70.

Cross, S.P. 1985. Responses of small mammals to forest riparian perturbations. In: Riparian ecosystems and their management: reconciling conflicting uses. Proc. First North American Riparian Conf., 16-18 April, 1985, Tucson, Arizona, pp. 269-275.

Darveau, M., P. Beauchesne, L. Belanger, J. Huot, and P. Larue. 1995. Riparian forest strips as habitat for breeding birds in boreal forest. J. Wildl. Manage. 59(1):67-68.

Franklin, J., D. Perry, R. Noss, D. Montgomery, and C. Frissel. 2000. Simplified forest management to achieve watershed and forest health: a critique. The Scientific Panel of Ecosytem-based Forest Management and the National Wildlife Federation, Washington D.C. 51 p.

Gomez, D.M. 1992. Small mammal and herpetofauna abundance in riparian and upslope areas of five forest conditions. Thesis, Oregon State University, Corvallis, Oregon, USA.

Gyug, L.W. 1995. Timber harvesting effects on riparian areas in the Montane Spruce zone of the Okanagan Highlands, B.C.: Annual progress report 1994/95. Part II: Interim breeding bird results. BC Min. Environ., Penticton, British Columbia. 24 p.

Hagar, J.C. 1999. Influence of riparian buffer width on bird assemblages in western Oregon. J. Wildl. Manage. 63(2):484-496.

Kinley, T.A. and N.J. Newhouse. 1997. Relationship of riparian reserve zone width to bird density and diversity in southeastern British Columbia. NW Sci 71:75-86.

Larsen, E.M. and Nordstrom, N., eds. 1999. Management recommendations for Washington's priority species, volume IV: birds. [Updated XX]. Washington Department of Fish and Wildlife, Olympia.

O'Connell, M.A., J.G. Hallett, and S.D. West. 1993. Wildlife use of riparian habitats: A literature review. TFW-WL1-93-001.

Roderick, E. and R. Milner, eds. 1991. Management recommendations for Washington's priority habitats and species. Washington Department of Wildlife, Olympia.

Rudolph, D.C. and J.G. Dickson. 1990. Streamside zone width and amphibian and reptile abundance. SW Nat. 35: 472-476.

Spackman, S.C. and J.W. Hughes. 1995. Assessment of minimum stream corridor width for biological conservation: Species richness and distribution along mid-order streams in Vermont, USA. Biol. Conserv. 71:325-332.

Vesely, D.G. 1997. Terrestrial amphibian abundance and species richness in headwater riparian buffer strips, Oregon Coast Range. Thesis, Oregon State University, Corvallis, Oregon, USA.

Slopes, Soils and Mass Wasting

Burroughs, E.R., and J.G. King. 1989. Reduction of soil erosion on forest roads. U.S.D.A. Forest Service, Intermountain Research Station. General Technical Report INT-264.

Chamberlin, T.W., R.D. Harr, and F.H. Everest. 1991. Timber harvesting, silviculture, and watershed processes. Pages 181-205. In: Influences of Forest and Rangeland Management on Salmonid Fishes and Their Habitats. American Fisheries Society Special Publication 19.

Keim, R.F., and Skaugset, A.E. 2003. Modeling effects of forest canopies on slope stability. Hydrological Processes, 17: 1457-1467.
Sidle, R.C., A.J. Pearce, and C.L. O'Loughlin. 1985. Hillslope Stability and Land Use. Water Resources Monograph 11. American Geophysical Union, Washington, D.C.

Krogstad, F. 1995. A physiology and ecology based model of lateral root reinforcement of unstable hillslopes. MSc. thesis, University of Washington, Seattle, WA.

Montgomery, D.R. 1994. Road surface drainage, channel initiation, and slope instability. Water Resources Research, 30 (6): 1925-1932.

Schmidt, K.M., J.J. Roering, J.D. Stock, W.E. Dietrich, D.R. Montgomery, and T. Schaub. 2001. The variability of root cohesion as an influence on shallow landslide susceptibility in the Oregon Coast Range. Canadian Geotechnical Journal, 38: 995-1024.

Sidle, R.C. 1992. A theoretical model of the effects of timber harvesting on slope stability. Water Resources Research, 28 (7): 1897-1910.

Wemple, B.C., F.J. Swanson, and J.A. Jones. 2001. Forest roads and geomorphic process interactions, Cascade Range, Oregon. Earth Surface Processes and Landforms, 26, 191-204.

Special Forest Products:

Alexander, A.G.; Alexander, S.J. 2002. Native U.S. plants in honey and pollen production. In: Jones, E.T.; McLain, R.J.; Weigand, J. Nontimber forest products in the United States, Lawrence, KS: University Press of Kansas: 223-236.

Alexander, S. J.; Weigand, J.; Blatner, K.A. 2002. Nontimber forest product commerce. In: Jones, E.T.; McLain, R.J.; Weigand, J. Nontimber forest products in the United States, Lawrence, KS: University Press of Kansas: 115-150.

Salmonids and Salmonid Habitat:

Beschta, R., et al. 1987. Stream temperature and aquatic habitat: Fisheries and forestry interactions, pages 191-232. In: E. O. Salo and T. W. Cundy (eds.), Streamside Management:

Forestry and Fishery Interactions. College of Forest Resources, University of Washington, Seattle.

Bjornn, T. C., and D. W. Reiser. Habitat requirements of salmonids in streams, pages 83-138. In: W. R. Meehan (ed.), Influences of Forest and Rangeland Management on Salmonid Fishes and Their Habitats. American Fisheries Society Special Publication 19, Bethesda, Maryland.

Bilby, R. E., and P. A. Bisson. 1992. Allochthonous versus autochthonous organic matter contributions to the trophic support of fish populations in clear-cut and old-growth forested streams. Canadian Journal of Fisheries and Aquatic Sciences 49:540-551.

Bisson, P. A., et al. 1987. Large woody debris in forested streams in the Pacific Northwest: Past, Present, and Future, pages 143-190. In: E. O. Salo and T. W. Cundy (eds.), Streamside Management: Forestry and Fishery Interactions. College of Forest Resources, University of Washington, Seattle.

Broderson, J. M. 1973. Sizing buffer strips to maintain water quality M.S.C.E. Thesis, University of Washington, Seattle. 86 p.

Bustard, D. R. 1973. Some aspects of winter ecology of juvenile salmonids with reference to possible habitat alteration by logging in Carnation Creek, Vancouver Island. Fisheries Research Board of Canada, Manuscript.

Bustard, D. R., and D. W. Narver. 1975a. Aspects of the winter ecology of juvenile coho salmon and steelhead trout. Journal of the Fisheries Research Board of Canada 32:667-680.

Bustard, D. R., and D. W. Narver. 1975b. Preferences of juvenile coho salmon and cutthroat trout relative to simulated alteration of winter habitat. Journal of the Fisheries Research Board of Canada 32:681-687.

Burner, C. J. 1951. Characteristics of spawning nests of Columbia River salmon. U. S. Fish and Wildlife Service Fishery Bulletin No. 61. Volume 52. Pages 95-110.

Cederholm, C. J., L. M. Reid, and E. O. Salo. 1981. Cumulative effects of logging road sediment on salmonid populations in the Clearwater River, Jefferson County, Washington, pages 38-74. Proceedings from the Conference – Salmon-Spawning Gravel: A Renewal Resource in The Pacific Northwest. State of Washington Water Research Center, Washington State University, Pullman.

Cederholm, C. J., and L. M. Reid. 1987. Impacts of forest management on coho salmon populations of the Clearwater River, Washington: A project summary, pages 373-399. In: E. O. Salo and T. W. Cundy (eds.), Streamside Management: Forestry and Fishery Interactions. College of Forest Resources, University of Washington, Seattle.

Cederholm, C. J. 1994. A suggested landscape approach for salmon and wildlife habitat protection in western Washington riparian ecosystems, pages 78-90. In: A. B. Carey and C.

Elliot (eds.) Washington Forest Landscape Management Project – Progress Report. Washington Department of Natural Resources.

Chamberlin, T. W., R. D. Harr, and F. H. Everest. 1991. Timber harvesting, silviculture, and watershed processes, pages 181-206. In: W. R. Meehan (ed.), Influences of Forest and Rangeland Management on Salmonid Fishes and Their Habitats. American Fisheries Society Special Publication 19, Bethesda, Maryland.

Chesney, C. J. 1982. Mass erosion occurrence and debris torrent impacts on some streams in the Willamette National Forest. M. S. Thesis, Oregon State University, Corvallis. 113 p.

Conners, M. E., and R. J. Naiman. 1984. Particulate allochthonous inputs: Relationships with stream size in an undisturbed watershed. Canadian Journal of Fisheries and Aquatic Sciences. 41:1473-1484.

Crawford, B. A. 1979. The origin and history of the trout brood stocks of the Washington Department of Game. Washington State Game Department fishery report. 76 p.

De Lisle, G. E. 1962. Water velocities tolerated by spawning kokanee. California Fish and Game 48:77-78.

Dominguez, L. 1997. Lake Whatcom Watershed Analysis – Fish Habitat Assessment. Washington Dejpartment of Natural Resources, Olympia.

Duncan, S. H., and J. W. Ward. 1985. The influence of watershed geology and forest roads on the composition of salmon spawning gravel. Northwest Science 59:204-212.

Erman, D. C., et al. 1977. Evaluation of streamside bufferstrips for protecting aquatic organisms. University of California, California Water Resources Center, Davis, CA. Contribution No. 165. 48 p.

Emmett, R. L., et al. 1991. Distribution and abundance of fishes and invertebrates in West Coast estuaries – species life history summaries. U. S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service, Rockville, MD. Estuarine Living Marine Resources Program ELMR report no. 8, v. 2, 329 p.

Everest, F. H. 1987. Fine sediment and salmonid production: A paradox, pages 98-142. In: E. O. Salo and T. W. Cundy (eds.), Streamside Management: Forestry and Fishery Interactions. College of Forest Resources, University of Washington, Seattle.

Forest Ecosystem Management Assessment Team. 1993. Forest ecosystem management: An ecological, economic, and social assessment. Report of the Forest Ecosystem Management Team. U. S. Department of Commerce; U. S. Department of Interior; and U. S. Environmental Protection Agency, Washington, D. C.

Foote, C. J. 1990. An experimental comparison of male and female spawning territoriality in a pacific salmon. Behavior 115:3-4.

Furniss, M. J., T. D. Roelefs, and C. S. Yee. 1991. Road construction and maintenance, pages 297-323. In: E. O. Salo and T. W. Cundy (eds.), Streamside Management: Forestry and Fishery Interactions. College of Forest Resources, University of Washington, Seattle.

Garrett, A. M. 1999. Interstream movements of coastal cutthroat trout in the Clearwater River, Jefferson County, Washington. Master of Environmental Studies Thesis, The Evergreen State College, Olympia, WA. 212 p.

Gregory, S. V., et al. 1987. Influence of forest practices on aquatic production, pages 233-256. In: E. O. Salo and T. W. Cundy (eds.), Streamside Management: Forestry and Fishery Interactions. College of Forest Resources, University of Washington, Seattle.

Grette, G. B. 1985. The role of large organic debris in juvenile salmonid rearing habitat in small streams. M. S. Thesis, University of Washington School of Fisheries, Seattle. 105 p.

Gratowiski,H. J. 1956. Windthrow around staggered settings in old-growth Douglas-fir. Forest Science 2:60-74.

Groot, C., and L. Margolis. 1991. Pacific salmon lifehistories. University of British Columbia Press. Vancouver, B. C. 564 p.

Hall, J. D., G. W. Brown, and R. L. Lantz. 1987. The Alsea Watershed Study: A retrospective, pages 399-416. In: E. O. Salo and T. W. Cundy (eds.), Streamside Management: Forestry and Fishery Interactions. College of Forest Resources, University of Washington, Seattle.

Hartman, G. F., and J. C. Scrivener. 1990. Impacts of forest practices on a coastal stream ecosystem, Carnation Creek, British Columbia. Canadian Bulletin of Fisheries and Aquatic Sciences 223. 148 p.

Heede, B. 1972. Flow and channel characteristics of two high mountain streams. USDA Forest Service Research Paper RM-96, 1 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.

Heggenes, J., T. G. Northcote, and A. Peter. 1991a. Spatial stability of cutthroat trout in a small, coastal stream. Canadian Journal of Fishereies and Aquatic Sciences 48:757-762.

Heggenes, J., T. G. Northcote, and A. Peter. 1991b. Seasonal habitat selection and preferences by cutthroat trout in a small, coastal stream. Canadian Journal of Fisheries and Aquatic Sciences 48:1364-1370.

Hunter, J. W. 1973. A discussion of game fish in the state of Washington as related to water requirements. Washington State Department of Game, Olympia.

June, J. A. 1981. Life history and habitat utilization of cutthroat trout in a headwater stream on the Olympic Peninsula, Washington. M. S. Thesis, University of Washington School of Fisheries. Seattle. 116.

Lestelle, L. C. 1978. The effects of forest debris removal on a population of resident cutthroat trout in a small headwater stream. M. S. Thesis, University of Washington School of Fisheries. Seattle. 86 p.

Liknes, G. A., and P. J. Graham. 1988. Westslope cutthroat trout in Montana: Life history, status, and management. American Fisheries Society Symposium 4:53-60.

Looff, A. 1994. Lake Whatcom kokanee management history and evaluation of recent population declines. M. S. Thesis College of Forest Resources, University of Washington, Seattle.

Lorz, H. W., and T. G. Northcote. 1965. Factors affecting stream location , and timing and intensity of entry by spawning kokanee into an inlet of Nicola Lake, British Columbia. Journal of the Fisheries Research Board of Canada 22:665-687.

Lynch, J. A., E. S. Corbett, and K. Mussallem. 1985. Best management practices for controlling nonpoint-source pollution on forested watersheds. Journal of Soil and Water Conservation. 40: 164-167.

Marston, R. A. 1982. The geomorphic significance of log steps in forest streams. Annals of the Association of American Geographers 72: 99-108.

Maser et al. 1988. From the forest to the sea: A story of fallen trees. U. S. Forest Service General Technical Report PNW-229.

Miller, R. B. 1954. Movements of cutthroat trout after different periods of retention upstream and downstream from their homes. Journal of the Fisheries Research Board of Canada. 11: 550-558.

Miller, R. B. 1957. Permanence and size of home territory in stream-dwelling cutthroat trout. Journal of the Fisheries Research Board of Canada.. 14:687-691.

Moore, K. M., and S. V. Gregory. 1988a. Response of young-of-the-year cutthroat trout to manipulation of habitat structure in a small stream. Transactions of the American Fisheries Society 117:162-170.

Moring, J. R. 1982. Decrease in stream gravel permeability after clear-cut logging: An indication of intragravel conditions for developing salmonid eggs and alevins. Hydrobiologia 88:295-298.

Murphy, L. M. , and K V. Koski. 1989. Input and depletion of woody debris in Alaska streams and implications for streamside management. North American Journal of Fisheries Management. 9:427-436.

Naiman, R. J. et al. 1992. Fundamental elements of ecologically healthy watersheds in the Pacific Northwest coastal ecoregion. In: R. J. Naiman (ed.). Watershed management balancing sustainability and environmental change. Springer-Verlag, New York, NY. P. 127-188.

Osborn, J. G. 1981. The effects of logging on cutthroat trout in small headwater streams. M. S. Thesis, University of Washington, School of Fisheries. 89 p.

Peterson, N. P. 1982a. Immigration of juvenile coho salmon into reiverine ponds. Can. J. Fish. Aquat. Sci. 39:1308-1310.

Peterson, N. P. 1982b. Population characteristics of Juvenile coho salmon overwintering in riverine ponds. Can. J. Fish. Aquat. Sci. 39:1303-1307.

Peterson, N. P., and L. M. Reid. 1984. Wall-base channels: Their evolution, distribution, and use by juvenile coho salmon in the Clearwater River, Washington, pages 215-226. In: J. M. Walton and D. B. Houston (eds.). Proceedings of the Olympia Wild Fish Conference. Held March 23-25, 1983. Fisheries Technology Program, Peninsula College, and Olympic National Park, Port Angeles.

Platts, W. S., and M. L. McHenry. 1988. Density and biomass of trout and char in western streams. U. S. Forest Service General Technical Report INT-241.

Potts, D. P., and B. K. M. Anderson. 1990. Organic debris and the management of small stream channels. Western Journal of Applied Forestry 5(1) 25-28.

Reid, L. M. 1981. Sediment production from gravel-surfaced forest roads, Clearwater Basin, Washington. M. S. Thesis, Department of Geological Sciences. University of Washington, Seattle.350 p.

Reid, L. M., and T. Dunne. 1984. Sediment production from forest road surfaces. Water Resources Research 20:1753-1761.

Richardson, J. S. 1992. Coarse particulate detritus dynamics in small, montane streams of southwestern British Columbia. Canadian Journal of Fisheries and Aquatic Sciences. 49: 337-346.

Ricker, W. E. 1940. On the origin of Kokanee, a freshwater type of sockeye salmon. Transactions of the American Fisheries Society 121:178-191.

Rieman, B. E., and D. L. Myers. 1992. Influence of fish density and relative productivity on growth of kokanee in ten oligotrophic lakes and reservoirs in Idaho. Transactions of the American Fisheries Society 121:178-191.

Robison, E. G., and R. L. Beschta. 1990. Identifying trees in riparian areas that can provide coarse woody debris to streams. Forest Science. 36:790-801.

Schuett-Hames, D. E. 1996. Effects of scour and fill on salmonid incubation habitat in Kennedy Creek, a low-gradient alluvial channel in Mason and Thurston Counties, Washington. Mater of Environmental Studies. The Evergreen State College, Olympia.. 58 p.

Sidle, R. C., A. J. Pearce, and C. L. O'Loughlin. 1985. Effects of land management on soil mass movement, pages 73-88. In: R. C. Sidle, A. J. Pearce, and C. L. O'Loughlin (eds.). Hillslope stability and land use. American Geophysical Union, Washington D. C. Water Resources Monograph 11.

Smith, A. K. 1973. Development and application of spawning velocity and depth criteria for Oregon salmonids. Transactions of the American Fisheries Society 102: 312-316.

Steinblums, I. J., H. A. Froehlich, and J. K. Lyons. 1984. Designing stable buffer strips for stream protection. Journal of Forestry. 82: 49-52.

Swanson, F. J., and C. T. Dyrness. 1975. Impact of clear-cutting and road construction on soil erosion by landsliding in the western Cascade Range, Oregon. Geology3: 393-396.

Swanson, F. J., et al.. 1987. Mass failures and other processes of sediment production in Pacific Northwest forest landscapes. In: E. O. Salo and T. W. Cundy (eds.), Streamside Management: Forestry and Fishery Interactions. College of Forest Resources, University of Washington, Seattle.

Swanston, D. N. 1991. Natural process, p. 139-179. In: W. R. Meehan (ed). Influences of Forest and Rangeland Management on Salmonid Fishes and Their Habitats. American Fisheries Society Special Publication 19, Bethesda, Maryland.

Thurow, R. F., and J. G. King. 1994. Attributes of Yellowstone cutthroat trout redds in a tributary of the Snake River, Idaho. Transactions of the American Fisheries Society. 123:37-50.

U. R. S. Engineers. 1985. Lake Whatcom water quality protection study – technical memorandum No. 2. Whatcom County, WA.

Van Sickle, J., and S. V. Gregory. 1990. Modeling inputs of large woody debris to streams from falling trees. Canadian Journal of Forest Research. 20:1593-1601.

Varley, J. D., amd R. E. Gresswell. 1988. Ecology, status, and management of the Yellowstone cutthroat trout. American Fisheries Society Symposium 4:93-106.

Washington Forest Practices Board. 1994. Board Manual: Standard Methodology for Conducting Watershed Analysis. Washington State Department of Natural Resources, Olympia.

Washington State Game Commission. 1947. Pages 32-33. In: Fisheries Biological Progress Report – April 1946-April 1947. Washington State Printing Plant, Olympia.

Wu, T. H., and D. N. Swanston. 1980. Risk of landslides in shallow soils and its relation to clearcutting in southeastern Alaska. Forest Science 26: 495-510.

APPENDIX E: CORRESPONDENCE

Correspondence between Commissioner of Public Lands Doug Sutherland and the Washington State Departments of Ecology and Health

WASHINGTON STATE DEPARTMENT OF
Natural Resources

DOUG SUTHERLAND
Commissioner of Public Lands

November 8, 2001

Megan White, Program Manager
Department of Ecology
300 Desmond Drive
PO Box 47600
Lacey, WA 98504-7600

Dear Megan,

Thanks for sharing information with me regarding Ecology's TMDL Water Quality Study (TMDL) for Lake Whatcom. It is very helpful, however I have a follow-up request for some additional information.

Engrossed Second Substitute Senate Bill 6731 directs the DNR to develop a landscape plan for approximately 15,00 acres of state-owned forestlands in the Lake Whatcom watershed area. Public comments made during the DNR EIS scoping process in September raised some questions about the relationship of the TMDL and the landscape plan – some suggesting that the DNR plan should wait for the completion of the TMDL. Their comments document that the perception by some members of the community is that state forestlands are a significant source of the water quality problems in the lake. One of principal objectives for the plan is to protect water quality.

In your November 1, 2001 e-mail to me you indicated that due to the length of the TMDL study (submit to EPA end of June 2004) "we don't think it makes sense to us to have you wait to complete the landscape plan. We think the risk of having to revisit your work is small since the likelihood, once the TMDL is completed, of our asking a property owner who is engaged in a land use activity that generates a comparatively low level of pollution is small. Moreover, from Ecology's perspective, it doesn't make sense to stop activities that are likely to lead to pollution reductions".

For DNR to successfully complete the landscape plan, prior to the completion of the TMDL, all stakeholders must have a clear understanding of the role state forest lands have on water quality in the Lake Whatcom watershed. That information is essential to balancing the necessary watershed protection and restoration with other forest management objectives and strategies.

Given the public's perception of DNR's forest management in relation to water quality in the watershed, it would be helpful if you would clarify in writing the Department of Ecology's understanding of the following:

1111 WASHINGTON ST SE ▮ PO BOX 47001 ▮ OLYMPIA, WA 98504-7001
FAX: (360) 902-1775 ▮ TTY: (360) 902-1125 ▮ TEL: (360) 902-1004
Equal Opportunity/Affirmative Action Employer

- The water quality pollution problems of the Lake Whatcom watershed
- Which of the pollution problems, and their approximate relative share, that originate on state forest land and
- What additional water quality protection measures, if any, should DNR consider beyond those already set forth in the Forest Practices Rules and the Lake Whatcom Watershed Analysis; the DNR Forest Resource Plan and HCP for state trust lands, and the additional requirements set forth in E2SSB 6731.

As you are aware, Steve Hood of Ecology is chair of the Lake Whatcom Landscape Planning Committee and is very knowledgeable of these requirements as they apply to Lake Whatcom. DNR Northwest Region staff tells me that Steve is doing a tremendous job as chair, as well as representing DOE.

I will be seeking similar Lake Whatcom water quality information from the Department of Health as it relates to the Safe Drinking Water Act.

The next meeting of the Lake Whatcom Landscape Planning Committee is scheduled for November 16th. Your written response, prior to then would allow us to share the information with the committee.

Thanks for your time and assistance.

Sincerely,

Doug Sutherland
Commissioner of Public Lands

Cc: Tom Fitzsimmons, Director, DOE

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
P.O. Box 47600 • Olympia, Washington 98504-7600
(360) 407-6000 • TDD Only (Hearing Impaired) (360) 407-6006

November 15, 2001

The Honorable Doug Sutherland
Commissioner of Public Lands
Department of Natural Resources
1111 Washington St. SE
P.O. Box 47001
Olympia WA 98504-7001

Dear Commissioner Sutherland:

Thank you for your interest in integrating the landscape planning activities that you are undertaking with Ecology's TMDL study of Lake Whatcom. Our experience to date indicates that the most successful TMDLs are those in which pollution reductions are implemented while data collection and analysis are taking place – before load allocations are even established.

While the Department of Natural Resource's "contribution" to pollution in Lake Whatcom is not expected to be a significant part of the problem, your efforts to evaluate and control pollution are a good example for all jurisdictions. When our TMDL study is complete in 2004, Ecology will likely require controls on the pollutants in stormwater. The areas where those controls are likely to be most needed are in the areas that have been developed. Pollution controls may be imposed as part of a stormwater permit issued to an appropriate jurisdiction by Ecology. The likelihood of Ecology imposing additional controls on pollution from commercial forestland is remote. Proper implementation and enforcement of forest practice rules should appropriately control pollution.

In your letter you asked for specific responses to three points. I have addressed each of them below.

- **The water quality pollution problems of the Lake Whatcom watershed**

Lake Whatcom fails clean water standards for dissolved oxygen. Low dissolved oxygen in the lake is partly caused by lake eutrophication processes. These processes are driven by the availability of nutrients and the physical conditions present in the lake during the summer and fall. In the case of Lake Whatcom, the limiting nutrient is phosphorus. Additions of phosphorus lead to greater production of algae. Dissolved oxygen is consumed as dead algae decomposed at the bottom of the lake.

The lake is also polluted with mercury. The problem is manifested in high levels of mercury in fish tissue. The mercury pollution problem is probably related to the dissolved oxygen problem. Profound and extended periods of anaerobic conditions (i.e., low/no oxygen) in the lake sediments favor conversion of mercury from inorganic forms to methylated forms. It is the methylated forms of mercury that bio-accumulate in fish tissue and are toxic to humans consuming fish.

The lake is also contaminated with PCBs, which have accumulated in fish tissue. The degree to which this contamination represents normal or abnormal levels in western Washington has not been determined. The level of contamination may represent ambient conditions for lakes in temperate regions of the world.

High levels of bacteria contaminate several of the tributaries of Lake Whatcom, though there are no indications of bacteria at the city of Bellingham's drinking water intake. Bacteria such as fecal coliform indicate a risk of exposure to pathogens when humans come into direct contact with polluted water during recreation or other water-based activities.

There have been suggestions that all of the tributaries of Lake Whatcom be placed on the 303(d) List for pollution of fine sediment. To date we have not received data to support this suggestion. Ecology's decision to propose listing based on fine sediment violations would require establishing an acceptable level of fine sediment for that particular waterbody, and documenting that unacceptable levels of sediments are due to human, rather than natural, causes. Forest practices have often been identified as a source of fine sediment pollution. However, Department of Natural Resource's compliance with current Forest Practice Rules should limit the contribution of fine sediment to streams from forestry activities. Until other sources have been similarly curtailed, we do not believe it would be appropriate to suggest additional reductions from forest sources.

- **Which of the pollution problems, and their approximate relative share, originate on state forest land**

Phosphorus enters a lake either through rain runoff (in its dissolved form) or by attaching to soil particles that are eroded into the lake. Historic forest practices that led to the mass wasting events of 1983 certainly contributed phosphorus to Lake Whatcom. However, recent forest practices such as Department of Natural Resource's watershed analysis and the Forest and Fish Agreement have focused on minimizing the risk of landslides. Phosphorus is essentially stripped from rainfall if stormwater is allowed to filter through forest soils. Overall, forestland is therefore expected to produce the lowest loads of phosphorus per acre.

It is also important to note that the problems with dissolved oxygen have been seen only in the most northern portions of the lake. Much of the phosphorus that enters the southern end of the lake is expected to settle to the bottom of the lake before it can impact the portion of the lake that has been identified as impaired.

Causes of increased phosphorus pollution of the lake are most likely the result of decreased permeability and increased runoff as the watershed around the lake is developed. Other sources include residential fertilizers and leakage from septic systems. Keeping land in forestland uses is an appropriate measure to protect against increasing phosphorus loading to the lake.

The sources of mercury in Lake Whatcom have not been fully evaluated but there is no reason to expect that forestry land uses are contributing to the problem unless airborne mercury pollution has been deposited over wide areas of trees for an extended period of time. Some of the potential mercury sources include natural mineral deposits, leacheate from historic mining activities or solid waste disposal sites, deposition by air from industrial sources, and runoff from pesticides containing mercury.

PCB contamination is a global problem that has reached far beyond near proximity to sources. It is unlikely that any of the activities on state lands are contributing to the PCB contamination in Lake Whatcom.

Fecal coliform contamination in the tributaries of the Lake Whatcom watershed is associated with human residential development. Tributary samples from forest areas typically do not contain fecal coliforms.

- **What additional water quality protection measures, if any, should Department of Natural Resources consider beyond those already set forth in the Forest Practices Rules and the Lake Whatcom Watershed Analysis; the Department of Natural Resources' Forest Resource Plan and HCP for state trust lands, and the additional requirements set forth in E2SSB 6731**

The controls you describe for the state lands in the Lake Whatcom watershed are currently the state of the art for reducing the risk of pollution from commercial forestland. Properly managed commercial forestland has been recognized as the most benign active land use for watershed protection for some time. The possibility of additional controls being imposed as a result of a Lake Whatcom TMDL is remote. Cleanup of Lake Whatcom is more likely to be focused on reducing pollution from non-forestry land uses.

I hope that these answers help you move forward with developing you Landscape Plan.

Sincerely,

Megan White, P.E., Manager
Water Quality Program

cc: Tom Fitzsimmons, Ecology Director

WASHINGTON STATE DEPARTMENT OF
Natural Resources

DOUG SUTHERLAND
Commissioner of Public Lands

November 8, 2001

Mary C. Selecky, Secretary
Washington State Department of Health
1112 SE Quince Street
PO Box 47890
Olympia, WA 98504-7890

Dear Mary:

I have some questions regarding water quality in the Lake Whatcom watershed. Given your agency' regulatory responsibility to implement the federal Safe Drinking Water Act, including source water protection plans, your response will be especially helpful.

As you probably are aware, Engrossed Second Substitute Senate Bill 6731 directs the DNR to develop a landscape plan for approximately 15,000 acres of state-owned forestlands in the Lake Whatcom watershed area. Public comments made during the DNR EIS scoping process in September raised questions about the relationship of Ecology's recently announced TMDL Water Quality Study (TMDL) for Lake Whatcom and the DNR landscape plan. Some comments even suggested that the DNR plan should wait for the completion of the TMDL. Their comments document that some members of the community perceive state forestlands to be a significant source of water quality problems in the lake. One of the principal objectives for the plan is to protect water quality.

For DNR to successfully complete the landscape plan, prior to the completion of the TMDL in 2004, all stakeholders must have a clear understanding of the role state forestlands have on water quality in the Lake Whatcom watershed. That information is essential to balancing the necessary watershed protection and restoration with other forest management objectives and strategies.

Given the public's perception of DNR's forest management in relation to water quality in the watershed, it would be helpful if you would clarify in writing the Department of Health's understanding of the following:

- Pollution sources identified in the Source Water Protection Plan for Lake Whatcom.
- Which of the pollution problems, and their approximated relative share, originate on state forest land and
- What additional water quality protection measures, if any, should DNR consider beyond those already set forth in the Forest Practices Rules and the Lake Whatcom Watershed Analysis; the DNR Forest Resource Plan and HCP for state trust lands; and the additional requirements set forth in E2SSB 6731.

1111 WASHINGTON ST SE ▮ PO BOX 47001 ▮ OLYMPIA, WA 98504-7001
FAX: (360) 902-1775 ▮ TTY: (360) 902-1125 ▮ TEL: (360) 902-1004
Equal Opportunity/Affirmative Action Employer

Richard Rodriguez of DOH is a member of the DNR Lake Whatcom Landscape Planning Committee and is familiar with these requirements as they apply to Lake Whatcom. DNR Northwest Region staff tell me that Richard is a tremendous asset to the committee.

I am seeking similar information about Lake Whatcom water quality from the Department of Ecology as it relates to the TMDL.

The next meeting of the DNR Lake Whatcom Landscape Committee is scheduled for November 16th. Your written response prior to then would allow us to share the information with the committee.

Many thanks for your help.

Sincerely,

Doug Sutherland
Commissioner of Public Lands

STATE OF WASHINGTON
DEPARTMENT OF HEALTH
1112 SE Quince Street • PO Box 47890
Olympia, Washington 98504-7890
tel: (360) 236-4010 • FAX (360) 586-7424
TDD Relay Service: 1-800-833-6388

November 27, 2001

The Honorable Doug Sutherland
Commissioner of Public Lands
Washington State Department of Natural Resources
1111 Washington Street Southeast
Post Office Box 47001
Olympia, Washington 98504-7001

Dear Mr. Sutherland:

Thank you for your recent letter regarding water quality in the Lake Whatcom watershed. I appreciate the opportunity to share with you and the Whatcom Landscape Committee our understanding of some of the issues surrounding the watershed. In addition, I would like to thank you for acknowledging the work of Richard Rodriguez. I will let him know that his efforts are appreciated.

The state's drinking water regulations require Group A water systems using surface water as a source of drinking water to develop watershed control programs. An essential element of a watershed control program is the identification of "activities/land uses detrimental to water quality." This element of the watershed control program should identify all activities/land use practices within the watershed that affect or have the potential to affect source water quality.

The Source Water Protection Plan for Lake Whatcom prepared by the City of Bellingham and Whatcom County Water District #10 (WCWD #10) identifies a number of activities, conditions, and land use practices within the watershed that have or could have an adverse impact on water quality. Additionally, these activities are prioritized by their potential to adversely impact water quality. These activities are generally classified as follows:

TIER 1: Residential development, municipal/commercial uses, and transportation;
TIER 2: Domestic livestock grazing and timber management;
TIER 3: On-site septic, recreation and fish and wildlife;
TIER 4: Mining;
TIER 5: Alluvial fans; and
TIER 6: Research and Education.

We expect that the City of Bellingham and WCWD #10 assess the public health risk associated with each of these types of activities/land uses.

It is our understanding that very few of the potential contaminant sources identified in the Source Water Protection Plan for Lake Whatcom could originate from State Forest Lands or DNR activities. In addition, the water treatment facilities located on Lake Whatcom have been designed and constructed in response to activities historically associated with the state forest lands. A significant increase in the intensity of an activity or a significant change in the type of activities that are occurring would, of course, cause us concern about water quality.

At this time, the Department is not requesting any changes to the programs and documents mentioned in your letter. We have not received requests from the Lake Whatcom purveyors or from our Water Supply Advisory Committee to seek changes to the water quality protection measures that they identify. It is our understanding that the Forest Practice Rules and the DNR Forest Resources Plan and HCP were developed to protect the environment; typically, practices that protect the environment usually protect drinking water sources.

The Department participated in DNR's 1999 Lake Whatcom Interagency Advisory Committee. That advisory committee developed water quality protection recommendations that targeted prevention or reduction of future sediment loads reaching Lake Whatcom from DNR's activities in the watershed. DNR should consider implementing the recommendations of that committee. As noted, the Department is currently participating in DNR's Lake Whatcom Landscape Plan advisory committee. Site-specific recommendations identified by that process related to enhancing water quality should also be considered.

If you should have any further questions, please contact Bob James, Division of Drinking Water, Northwest Regional Office at 360-395-6768.

Sincerely,

Mary C. Selecky
Secretary

cc: Bob James
Richard Rodriguez